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**WIGWAM RIVER JUVENILE BULL TROUT
AND FISH HABITAT MONITORING
PROGRAM: 2000 DATA REPORT**



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B O N N E V I L L E P O W E R A D M I N I S T R A T I O N



Wigwam River Juvenile Bull Trout and Fish Habitat Monitoring Program: 2000 Data Report.



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Executive Summary

The Wigwam River juvenile bull trout and fish habitat monitoring program is a co-operative initiative of the British Columbia Ministry of Environment, Lands and Parks and Bonneville Power Administration. The Wigwam River has been characterized as the single most important bull trout spawning stream in the Kootenay Region. This report provides a summary of results obtained during the inaugural year (2000) of the juvenile bull trout enumeration and fish habitat assessment program. This project was commissioned in planning for fish habitat protection and forest development within the upper Wigwam River valley. The broad intent is to develop a better understanding of juvenile bull trout and Westslope cutthroat trout recruitment and the ongoing hydrologic and morphologic processes in the upper Wigwam River, especially as they relate to spawning and rearing habitat quality.

Five permanent sampling sites were established in the Wigwam river drainage (one site on Bighorn Creek and four sites on the mainstem Wigwam River). At each site, juvenile (0+, 1+ and 2+ age classes) fish densities and stream habitat conditions were measured over two stream meander wavelengths.

Bull trout represented 92.4% of the catch and the mean density of juvenile bull trout was estimated to be 17.2 fish/100m² (range 0 to 26.9 fish/100m²). The precision of the mean density estimate for bull trout fry was +/- 20%. Fry (0⁺) dominated the catch and this was a direct result of juvenile bull trout ecology and habitat partitioning among life history stages. Site selection was biased towards sample sites which favored high bull trout fry capture success.

Comparison of fry density estimates replicated across both the preliminary survey (1997) and the current study (2000) illustrate the stable nature of these high densities. Bull trout populations have been shown to be extremely susceptible to habitat degradation and over-harvest and are ecologically important as an indicator of watershed health. As such, the upper Wigwam River watershed remains relatively pristine, and maintains high water quality and high habitat capability. Conservative angling regulations have been successful in preventing over-harvesting.

Differences in hydraulic conditions between the 1999 and the 2000 spawning and incubation period will provide significant contrast for proposed sampling in August 2001. The error term associated with the morphological survey was between 0.7 and 9 mm per 100 m; thus the survey data can meet precision levels to determine if site-specific impacts are occurring.

Acknowledgements

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Table of Contents

EXECUTIVE SUMMARY	I
ACKNOWLEDGEMENTS	II
TABLE OF CONTENTS	III
LIST OF TABLES	IV
LIST OF FIGURES.....	V
1 INTRODUCTION.....	1
1.1 Objectives	1
1.2 Study Area	3
1.2.1 Forest Development Status	4
1.2.2 Fisheries Resource Status.....	5
2 METHODS	6
2.1 Juvenile Enumeration	6
2.2 Fish Habitat Assessment	7
3 RESULTS	9
3.1 Juvenile Fish Sampling.....	11
3.1.1 Species Composition and Distribution	11
3.1.2 Bull Trout.....	11
3.1.3 Westslope Cutthroat Trout.....	14
3.2 Physical Habitat Monitoring.....	16
3.2.1 Water Temperature and Discharge.....	16
3.2.2 Substrate Pebble Counts.....	18
3.2.3 Fish Habitat Survey (FHAP Form 4)	19
3.2.4 Channel Survey	26
4 DISCUSSION.....	28
5 REFERENCES.....	31
APPENDIX A 1:50,000 TRIM Map	
APPENDIX B Fish Capture Data	
APPENDIX C FHAP Level 1 Form 4 Data	
APPENDIX D Channel Survey Data	

List of Tables

Table 3.1. Schedule of program field components for the Wigwam River bull trout and fish habitat monitoring program, 2000.....	9
Table 3.2. Summary of permanently established bull trout and fish habitat sample sites within the Wigwam River study area and associated site designations for on-going and previous surveys conducted in the immediate vicinity.	10
Table 3.3. Summary of fork length and weight data, by estimated age cohort, collected from bull trout captured within the Wigwam River drainage, 9-14 August 2000.	12
Table 3.4. Mean density estimates (+/- 95% confidence interval) for bull trout fry within the upper Wigwam River permanent sample sites, 9-14 August 2000.....	13
Table 3.5. Summary of fork length and weight data, by estimated age cohort, collected from Westslope cutthroat trout captured within the Wigwam River drainage, 9-14 August 2000.....	14
Table 3.6. Summary of water temperature, mean velocity, and discharge measurements for the Wigwam River fish habitat monitoring sites.	16
Table 3.7 Summary of substrate pebble counts (mode, D50, D90) for the Wigwam River fish habitat monitoring sites.	19
Table 3.8. Diagnostics of salmonid habitat condition at the reach level (from Johnston and Slaney 1996). Note that the individual cell format represents value/rating.....	20
Table 4.1. Comparative bull trout fry density estimates for 1997 and 2000 surveys.....	28

List of Figures

Figure 1.1. Location of Wigwam River Study Area	2
Figure 3.1. Length frequency distribution and estimated age cohorts for Wigwam River juvenile bull trout (0+ to 2+ age classes).....	12
Figure 3.2. Length-weight regression for bull trout captured within the upper Wigwam River watershed, 9-14 August 2000.....	13
Figure 3.3. Length frequency distribution and estimated age cohorts for Wigwam River Westslope cutthroat trout juveniles.	15
Figure 3.4. Length-weight regression for Westslope cutthroat trout captured within the upper Wigwam River watershed, 9-14 August 2000.	15
Figure 3.5. Mean daily discharge and total precipitation at the hydrometric station (Reach 5 EMS No. E238242) in 1999 and 2000 (Prince and Cope 2001).	17
Figure 3.6. Mean daily water levels recorded at the hydrometric station and groundwater station (Reach 7, EMS No. 238246), 2000 (Prince and Cope 2001).....	17
Figure 3.7. Daily maximum water temperatures recorded at the hydrometric station (Reach 5, EMS No. E238242) and the groundwater station (Reach 7, EMS No. 238246), 2000 (Prince and Cope 2001).....	18
Figure 3.8. Representative habitat within permanent sample site one, reach five, Wigwam River.	21
Figure 3.9. Downstream aerial view of permanent stream survey site two, reach six, Wigwam River.	22
Figure 3.10. Downstream view of representative habitat within permanent stream survey site three, reach seven, Wigwam River.	23
Figure 3.11. Downstream view of representative habitat within permanent stream survey site four, reach nine, Wigwam River.	24
Figure 3.12. Downstream view of representative habitat within permanent stream survey site one, reach one, Bighorn creek.	25

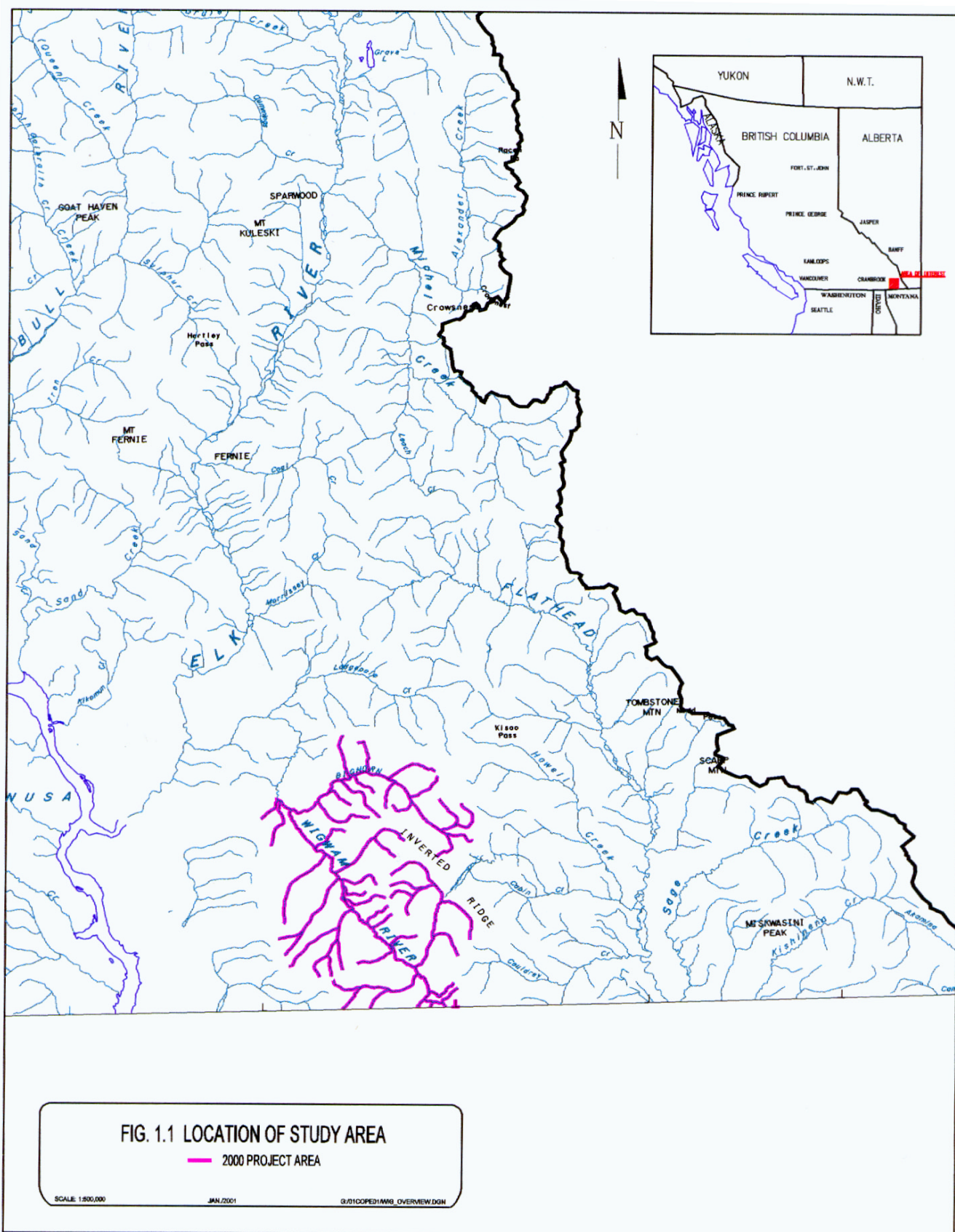
1 Introduction

The Wigwam River bull trout (*Salvelinus confluentus*) and fish habitat monitoring program is a trans-boundary initiative implemented by the British Columbia Ministry of Environment, Lands and Parks (MOE), in cooperation with Bonneville Power Administration (BPA). The Wigwam River is an important fisheries stream located in southeastern British Columbia that supports healthy populations of both bull trout and Westslope cutthroat trout (Figure 1.1). This river has been characterized as the single most important bull trout spawning stream in the Kootenay Region (Baxter and Westover 2000, Cope 1998). In addition, the Wigwam River supports some of the largest Westslope cutthroat trout (*Oncorhynchus clarki lewisi*) in the Kootenay Region. These fish are highly sought after by anglers (Westover 1999a, 1999b).

Bull trout populations have declined in many areas of their range within Montana and throughout the northwest including British Columbia. Bull trout were blue listed as vulnerable in British Columbia by the B.C. Conservation Data Center (Cannings 1993) and although there are many healthy populations of bull trout in the East Kootenays they remain a species of special concern. Bull trout in the United States portion of the Columbia River were listed as threatened in 1998 under the Endangered Species Act by the U.S. Fish and Wildlife Service. The upper Kootenay River is within the Kootenai sub-basin of the Mountain Columbia Province, one of the eleven Eco-provinces that make up the Columbia River Basin. MOE applied for and received funding from BPA to assess and monitor the status of wild, native stocks of bull trout in tributaries to Lake Koocanusa (Libby Reservoir) and the upper Kootenay River. This task is one of many that was undertaken to "Monitor and Protect Bull Trout for Koocanusa Reservoir" (BPA Project Number 2000-04-00).

1.1 Objectives

Five permanent sampling sites were to be established in the Wigwam river drainage (one site on Bighorn Creek and four sites on the mainstem Wigwam River). At each site, juvenile fish densities and stream habitat conditions will be measured annually. The broad intent of this project was to develop a better understanding of inter-annual variation in juvenile bull trout and Westslope cutthroat trout recruitment and the ongoing hydrologic and morphologic processes in the upper Wigwam River, especially as they relate to spawning and rearing habitat quality and timber harvest development.



1.2 Study Area

The Wigwam River originates in the Rocky mountains within the state of Montana and flows northwest between the Galton and MacDonald ranges in British Columbia for approximately 47 km until it empties into the Elk River, a tributary to Lake Koocanusa (Figure 1.1). The headwaters of the Wigwam drainage originate at an elevation of 2,135 m and declines to 763 m. The Wigwam River valley is characterized by four biogeoclimatic zone variants; Kootenay dry mild interior Douglas-fir, dry cool montane spruce, Kootenay moist cool interior cedar hemlock, and dry cool Engelmann spruce sub-alpine fir (Braumandl and Curran 1992).

The flow regime of the Wigwam River is comparable to most interior systems with high annual run-off reaching it's peak in May (peak mean daily discharge $74 \text{ m}^3/\text{s}$ on 24 May 2000) and expected low flows in late fall and winter ($2.1 \text{ m}^3/\text{s}$; Prince and Cope 2001). Freeze up generally occurs in mid to late November however, areas of groundwater infiltration remain open in most years. The temperature signature recorded in the mainstem Wigwam River in the vicinity of the spawning grounds was indicative of groundwater and daily maximum temperatures within the upper Wigwam river do not exceed 14.5°C (Prince and Cope 2001, 2000).

The upper reaches of the Wigwam River occupy a glacial outwash channel that is bounded by glacial till terraces and silt seams. The occurrence of lacustrine silt deposits overlain by highly permeable glacial till within adjacent terraces has contributed to a predominance of sub-surface flow that reaches the mainstem as groundwater. The influence of groundwater has been a large factor in the maintenance of cool stream temperatures and annual low flows (Prince and Cope 2000, 2001). A number of natural disturbance events over time appear to have contributed a substantial volume of coarse sediment to the river including: wildfires in the 1930's, a slide in 1993, and the 1995 flood event thought to occur every 100 to 200 years (Oliver and Cope 1999). Sediment aggradation throughout a broad, alluvial floodplain is associated with channel-confining bedrock outcrops. The combination of frequent lateral migration and erosion of adjacent terraces and coarse sediment delivery to the mainstem river has created a braided channel comprised of sorted gravels and cobbles that provide prime spawning habitat for bull trout (Oliver and Cope 1999). The provision of suitably sized bed materials ($<20 \text{ mm}$) in a low gradient, low water velocity location with

associated groundwater have been identified as repeating patterns of preferred bull trout spawning habitat (McPhail and Baxter 1996).

1.2.1 Forest Development Status

Forest harvesting and accompanying road development in the Wigwam basin have, to date, been undertaken primarily in Montana, where approximately 20% of the watershed was logged (with extensive road network) in the 1950's and 1960's with subsequent 'green-up' ongoing to the present day (Anon. 1999). In the Canadian portion of the watershed, logging has been limited to the Rabbit Creek sub-basin (< 100 ha), with some helicopter logging in the 1990's near the confluence of the Wigwam River with the Elk River. Conventional logging occurred approximately 20 years ago in the vicinity of the confluence with the Elk River, and in the Bighorn Creek sub-basin. British Columbia Watershed Restoration Program (WRP) activities have been on-going within the Bighorn Creek watershed since 1995 (Cope 2000).

The original CFI Forest Development Plan (FDP; CFI 1999) has gone through several iterations in response to stakeholder concerns. The current plan (commonly referred to as amendment 5) calls for logging a total of 646 ha (1.7% of the entire watershed) or 161,000 m³ of harvest volume, over a three to four year period after which no further harvesting is planned for 20 years. Lodgepole pine is the predominant species to be harvested. All cutblocks are on glacial till terraces in the valley bottom and are to be clear-cut. Forest development activities for the 2000 works windows included the construction of approximately 30 km of mainline Forest Service Road, spur roads, and the installation of five bridges; including one full span crossing of the upper Wigwam River. Harvesting commenced in December 2000.

Forest development plans for the Wigwam River watershed have come under considerable scrutiny because of potential impacts to bull trout habitat. Of the proposed forest development activities, 85% are located upstream of 70% of the principal bull trout spawning congregations. The issues have largely centered on block size, water temperature, increased sediment yield, and base flow levels in the mainstem river. Due to the valley's wildfire history, the creation of extensive openings in a largely even-aged, lodgepole pine forest are intended to mimic a natural stand initiating event. The size of the proposed clear-cuts however, are perceived to alter basin hydrology, affect the annual flow

regime (both peak and base flows) and encourage surface erosion that could lead to fine sediment delivery.

1.2.2 Fisheries Resource Status

When compared to other bull trout systems, it can be argued that the Wigwam River may be the most prolific bull trout population in the species distribution range. Juvenile densities are some of the highest densities reported within the literature (Cope 1998) and spawning escapements consistently exceed 1,000 fish (Baxter and Westover 2000). Baxter and Westover (2000) provide a thorough review of the biology, population status, and scientific studies to date for this population. The principle concerns for the Wigwam River population center around the potential impacts of forest harvesting. Bull trout are adapted to cold water temperatures and thrive in waters that are too cold, unproductive or too steep in gradient for other fish. Bull trout are not found in streams where maximum monthly water temperatures exceed 18°C and are most abundant where water temperatures are 12°C or less (Goetz 1989, Ford *et. al.* 1995, McPhail and Baxter 1996, Buchanan and Gregory 1997). This preference for cooler water manifests in the frequent association of bull trout with cold perennial springs (Oliver 1979, Goetz 1989, McPhail and Baxter 1996, Buchanan and Gregory 1997). In general, the species does not occur in high densities, a tendency that is partly due to the life-history strategy and the environment in which they live. Low population densities, slow growth, delayed maturation and high quality habitat requirements (water temperatures < 14°C, spawning gravel with low % fines) make bull trout sensitive to habitat degradation and over-harvesting (Goetz 1989, Fraley and Shepard 1989, Ratliff *et. al.* 1996, Ford *et. al.* 1995, McPhail and Baxter 1996).

Westslope cutthroat trout are also typical of cold, nutrient poor streams (Liknes and Graham 1988). The Wigwam River population of Westslope cutthroat trout contains appreciable numbers of large individuals with adults attaining 450 mm fork length (Westover and Conroy 1997). Although the distribution and abundance of Westslope cutthroat trout have drastically declined from its historic range during the last 100 years, the abundance and size of the current Wigwam River population may be attributed to the combination of special regulations designed to limit harvest and high quality available habitat.

2 Methods

Five permanent sampling sites were established in the Wigwam river drainage (reaches 5, 6, 7, and 9 of the Wigwam River, and reach 1 of Bighorn Creek, see attached 1:50,000 TRIM map). Sampling sites were a minimum of 20 channel widths in length or a distance equal to two stream meander wavelengths. At each site the following reference points were permanently established, geo-referenced and marked with a combination of metal tree tag, tree blaze, fluorescent tree paint, and flagging tape:

- Upstream and downstream elevation benchmarks. Elevation benchmarks were also represented by a lag bolt imbedded in the base of a large, stable, riparian tree,
- Upstream and downstream limits of the longitudinal survey,
- Riffle and pool cross-sectional reference points, and
- Electrofishing habitat units.

The following methods outline the specific assessments completed at each of the five permanently established sites.

2.1 Juvenile Enumeration

Estimates of juvenile fish density (number of fish/100 m²) were determined using closed, maximum-likelihood removal estimates (Riley and Fausch 1992). For each site, three habitat units (riffle, pool and run) were individually sampled for fish densities over a minimum of 100 lineal meters and/or 500 m². This methodology allows for habitat unit comparisons as well as reach comparisons through pooling of habitat units to obtain a mean. A Smith-Root Mark 12POW backpack electroshocker was used for successive depletions within each closed sample unit. Although bull trout are the main focus of this project, densities of all fish captured were reported.

Where possible and appropriate, the exact habitat units of the preliminary 1997 study were sampled. The project biologist and lead technician were also members of the original enumeration crew further ensuring consistency and minimization of sampler bias.

Catch results from individual habitat units were summed, by pass, at each representative reach location. These results were then used to estimate the number of fry and juveniles (1⁺ and 2⁺ age classes) within the composite enclosure area. Population estimates were calculated using the “Microfish” software package (Van Deventer and Platts 1990).

Population estimates and their 95% confidence interval were then reported as a standard numerical density (number fish/100 m²).

2.2 Fish Habitat Assessment

A standard suite of habitat parameters were collected using the Resource Inventory Committee (RIC) approved Fish Habitat Assessment Procedures (FHAP), Level 1, Form 4 - Habitat Survey Data Form (Johnston and Slaney 1996). The level 1 FHAP a purposive field survey of current habitat conditions for the target species in select reaches. This form has been developed for interpretation of habitat sensitivity and capability for fish production and includes prominent physical features such as pool and riffle ratios, residual pool depths, channel stability, flood indicators, cover components, abundance of large woody debris (LWD), and riparian vegetation.

Following methods described in Rosgen (1996) the following measurement of channel bed, channel bank and fish habitat parameters were also completed:

- A longitudinal profile (two stream meander wavelengths) of the stream-bed following the thalweg of the stream channel and water surface (slope),
- Stream cross-sections on both a riffle and pool segment,
- Modified Wolman pebble count, and
- Stream discharge and bank full width.

Geomorphic surveys utilized a Laserplane 220 leveling station and target rod (Spectraphysics, Dayton, Ohio, U.S.A.) and standard differential hydrometric survey techniques (Anon. 1998). Arbitrarily established benchmarks were blazed, flagged and marked with metal locator tags and geo-referenced. The UTM coordinates were overlain on the digital Nad 83 Forest Cover Trim Sheet and the elevation data corrected to this datum. At 10 m intervals, following the thalweg of the stream channel, the elevation of the stream bed and the water surface was surveyed over the length of the study area. All stream and habitat unit gradients were calculated from differences in water surface elevation. Cross sectional profiles were surveyed at 1 m intervals and extended 5 m beyond the bankfull width. The elevation of the bankfull channel was also noted at each cross section location. All survey loops were closed and error levels expressed to ensure quality control.

Channel bed material characterization employed the modified Wolman method outlined in Rosgen (1996). Briefly, this procedure uses a stratified, systematic sampling method based on the frequency of riffle/pools and step/pools occurring within a channel reach that is approximately 20-30 bankfull channel widths in length (or two meander wavelengths). The modified method adjusts the material sampling locations so that various bed features are sampled on a proportional basis along a given stream reach. In total, 10 transects are established and ten substrate particles are selected at systematic intervals across the bankfull channel width, for a total sample size of 100. The intermediate axis of the particle was measured such that the particle size selected would be retained or pass a standard sieve of fixed opening. The composite particle distribution was used to represent the site. To avoid potential bias, the actual particle was selected on the first blind touch, rather than visually selected.

Stream discharge was estimated at each location using a Price 1210AA velocity meter and wading rod calibrated bi-annually by the National Calibration Service of the National Water research Institute. All methods meet national and provincial standards and have demonstrated precision levels of less than +/- 5% (Prince and Cope 2000, 2001).

3 Results

Five permanent fish and fish habitat sampling locations were established within the upper Wigwam valley and included four locations on the Wigwam River mainstem and one location within Bighorn Creek (Table 3.1). Sample sites were a minimum of two stream meander wavelengths and ranged from 265 to 670 lineal meters. The upper and lower geo-reference points (uncorrected) for each site are summarized below in Table 3.2. For the corrected UTM coordinates see the attached 1:50,000 TRIM map (Appendix A). The corresponding site numbers of the preliminary sampling program (Cope 1998) and MOE Environmental Monitoring System (EMS) sites (Prince and Cope 2000, 2001) were also included for reference between these complimentary monitoring programs.

Reaches five and seven replicated the precise habitat units of the preliminary 1997 survey. Reach nine was repositioned due to access constraints. Reach six of the Wigwam river and reach one of Bighorn Creek were repositioned to more accurately address the specific bull trout and fish habitat objectives of the long-term monitoring program.

Additional background data of varying levels of applicability and accuracy (*i.e.* previous streambed and cross-sectional surveys, pebble counts, water quantity and quality data) can be accessed through the EMS data storage initiative (MOE, Nelson, B.C.) and the British Columbia WRP program (MOE, Cranbrook, B.C.).

Table 3.1. Schedule of program field components for the Wigwam River bull trout and fish habitat monitoring program, 2000.

Program Component	Date
Establishment of Permanent Sample Sites	August 9 - 14
Juvenile Fish Density Sampling	August 9 - 14
Level 1 FHAP Form 4 Measurements and Channel Surveys	September 20 – October 4
Aerial Reconnaissance Survey (Channel Dewatering, Groundwater Influence, Forest Development)	January 22

Table 3.2. Summary of permanently established bull trout and fish habitat sample sites within the Wigwam River study area and associated site designations for on-going and previous surveys conducted in the immediate vicinity.

Sample Site	UTM (Zone.Easting.Northing)	1997 Site No. ¹	EMS No. ²	Additional Habitat Data ³
Wigwam R. Reach 5 Site 1	11.648335.5449685 11.648110.5449910	2	E238242 ^a	
Wigwam R. Reach 6 Site 2	11.653886.5441349 11.653802.5441896	4 & 5 ^b		CS1
Wigwam R. Reach 7 Site 3	11.655471.5438625 11.654977.5439074	6 & 7	E238246	
Wigwam R. Reach 9 Site 4	11.661031.5432738 11.660942.5432911		E238250	CS2
Bighorn Cr. Reach 1 Site 1	11.648335.5449685 11.649089.5449439	13 ^c		WRP1

¹ – Site numbers from preliminary bull trout and fish habitat monitoring program (Cope 1998). Data includes juvenile enumeration, RIC inventory site card, pebble count and discharge estimation.

² – MoELP EMS site numbers from ongoing upper Wigwam River water quantity and quality inventory project (Prince and Cope 2000, 2001). Data includes water quantity and quality monitoring data.

³ – CS1 and CS2 site numbers from upper Wigwam River water quantity and quality inventory project (Prince and Cope 2000). Data includes FHAP Form 4, longitudinal and cross-sectional profiles, pebble counts and discharge estimation. WRP1 represents Watershed Restoration Program level II FHAP longitudinal (900 lineal meters) and cross-sectional profiles (n=11) (Cope and prince 2000).

^a – Hydrometric and automated water quality grab station located 1 km upstream.

^b – Site 4 was 200 m downstream (dewatered due to down-cutting) and Site 5 was 400 m upstream.

^c – Site 13 was 300 m upstream.

3.1 Juvenile Fish Sampling

3.1.1 Species Composition and Distribution

In total, 14 habitat units were sampled across five reaches (41,454 seconds of backpack electrofishing effort over 2,599 m²; Appendix B). Both bull trout and Westslope cutthroat trout were captured in all reaches sampled. A total of 419 fish were captured within the Wigwam River and Bighorn Creeks during the sample period 9 -14 August 2000. Bull trout were the dominant species encountered, representing 92.4% (n = 387) of the total catch. The remaining 7.6% of the total catch was represented by Westslope cutthroat trout (n = 32). Bull trout fry were the target species and life stage and as such, the catch composition reflects bias associated with site selection for this capture target. Rocky mountain whitefish (*Prosopium williamsoni*) and rainbow trout (*Oncorhynchus mykiss*) have been reported in lower reaches and were not encountered in the present study.

3.1.2 Bull Trout

In total, 387 bull trout were captured and sampled for life history information (Table 3.3). All captured bull trout were juveniles and ranged in age class from 0⁺ to 2⁺ (Figure 3.1). These fish ranged in fork length from 24 mm to 164 mm and the modal class, in 10 mm intervals, was 51-60 mm. This size class represents the young-of-the-year cohort (fry, 0⁺). The relative proportions of age classes comprising the total bull trout catch was 95.6% fry (0⁺), 3.9% (1⁺), and 0.5% (2⁺). Mean fork lengths of each age class (estimate) were 53.9 (0⁺), 101.7 (1⁺), and 157 (2⁺) mm. The corresponding mean weights for bull trout age classes were 1.7, 11.7 and 39.0 g respectively (Table 3.3). The growth rate of juvenile bull trout in the Wigwam River study area was described by the equation:

$$\text{Log}_{10}\text{Weight} = -4.6343 + 2.7971\text{Log}_{10}\text{Length} \text{ (Figure 3.2).}$$

Mean density of juvenile bull trout (ages 0⁺ to 2⁺) was estimated to be 17.2 fish/100m² with a range of 0 to 26.9 fish/100m² (Appendix B). Fry (0⁺) abundance represents the 1999 broodyear egg-to-fry recruitment and mean density was estimated to be 14.7 fry/100m² ranging from 9.2 to 26.9 fry/100m² (Table 3.4). Trends in abundance appeared to be related to proximity to spawning areas, bed material size, water depth, cover and macro-habitat type sampled (i.e. glide margin).

Bull trout captures of the 1⁺ and 2⁺ age classes were far less abundant than those of fry. Even when both age classes were combined, captures were not sufficient to generate density estimates. Low densities were largely due to electrofishing capture inefficiencies

Table 3.3. Summary of fork length and weight data, by estimated age cohort, collected from bull trout captured within the Wigwam River drainage, 9-14 August 2000.

	<i>Age-Group</i>		
	0 ⁺	1 ⁺	2 ⁺
Mean Fork Length (mm)	53.9	101.7	157
Standard Error	0.3	3.3	7
Range	24-72	82-127	150-164
N	370	15	2
Mean Weight (g)	1.7	11.7	39
Standard Error	0.03	1.2	4.1
Range	0.4-3.7	5.5-24.3	34.9-43.0
N	341	15	2

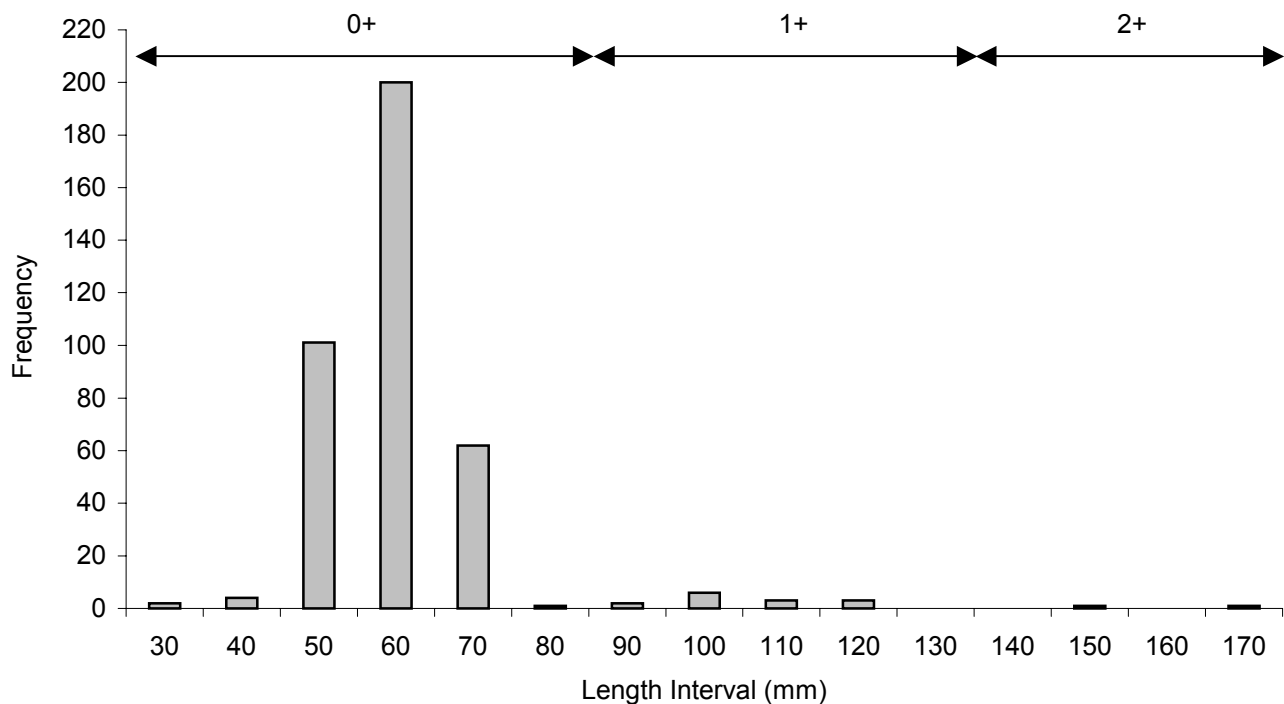


Figure 3.1. Length frequency distribution and estimated age cohorts for Wigwam River juvenile bull trout (0+ to 2+ age classes).

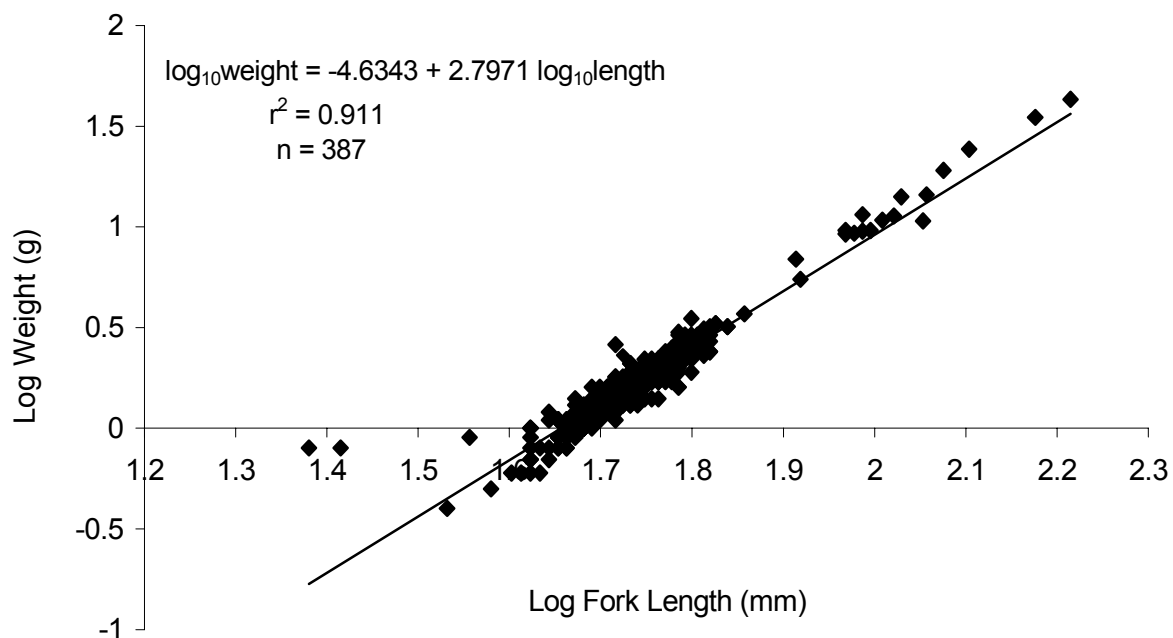


Figure 3.2. Length-weight regression for bull trout captured within the upper Wigwam River watershed, 9-14 August 2000.

Table 3.4. Mean density estimates (+/- 95% confidence interval) for bull trout fry within the upper Wigwam River permanent sample sites, 9-14 August 2000.

Bull trout sample site location	Density Estimate:
	Number of fry/100m ² (+/- 95% confidence interval)
Wigwam River - Reach 5, Site 1	17.1 (14.7 – 19.8)
Wigwam River - Reach 6, Site 2	26.9 (23.3 – 30.4)
Wigwam River - Reach 7, Site 3	16.4 (16.0 – 17.3)
Wigwam River - Reach 9, Site 4	9.2 (8.6 – 10.5)
Bighorn Creek – Reach 1, Site 1	15.6 (10.5 – 24.1)

associated with juvenile bull trout ecology and habitat partitioning among life history stages. Site selection was biased towards electrofishing sample sites which favored high bull trout fry capture success. Such sites typically have lower 1⁺ and 2⁺ age class bull trout densities.

3.1.3 Westslope Cutthroat Trout

In total, 32 Westslope cutthroat trout were captured and sampled for life history information (Table 3.5). Cutthroat trout ranged in age from 0⁺ to 3⁺ indicating the primary use of sampled habitat was by rearing juveniles. Cutthroat fork lengths ranged from 21 mm to 184 mm. Mean fork length was 24.6 (0⁺), 76.6 (1⁺), 136.5 (2⁺), and 184 (3⁺) mm. The modal length, in 10 mm intervals, was 21-30 mm and the length-frequency histogram illustrates the fry (0⁺) life-stage dominated the catch (Figure 3.3). The relative contribution to the catch was 68.8% fry, 21.8% (1⁺), 6.3% (2⁺), and 3.1% (3⁺). The corresponding mean weights were 0.8, 5.3, 29.2, and 71.7 g, respectively (Table 3.5). The growth rate of Westslope cutthroat trout in the Wigwam River study area was described by the equation:

$$\text{Log}_{10}\text{Weight} = -9786.3 + 234.23\text{Log}_{10}\text{Length} \quad (\text{Figure 3.4}).$$

Table 3.5. Summary of fork length and weight data, by estimated age cohort, collected from Westslope cutthroat trout captured within the Wigwam River drainage, 9-14 August 2000.

	<i>Age-Group</i>			
	0 ⁺	1 ⁺	2 ⁺	3 ⁺
Mean Fork Length (mm)	24.59	76.57	136.5	184
Standard Error	0.48	4.09	1.5	0
Range	21-29	68-98	135-138	184
N	22	7	2	1
Mean Weight (g)	0.83	5.27	29.15	71.7
Standard Error	0.014	0.89	0.65	0
Range	0.7-0.9	3.2-10.1	28.5-29.8	71.7
N	22	7	2	1

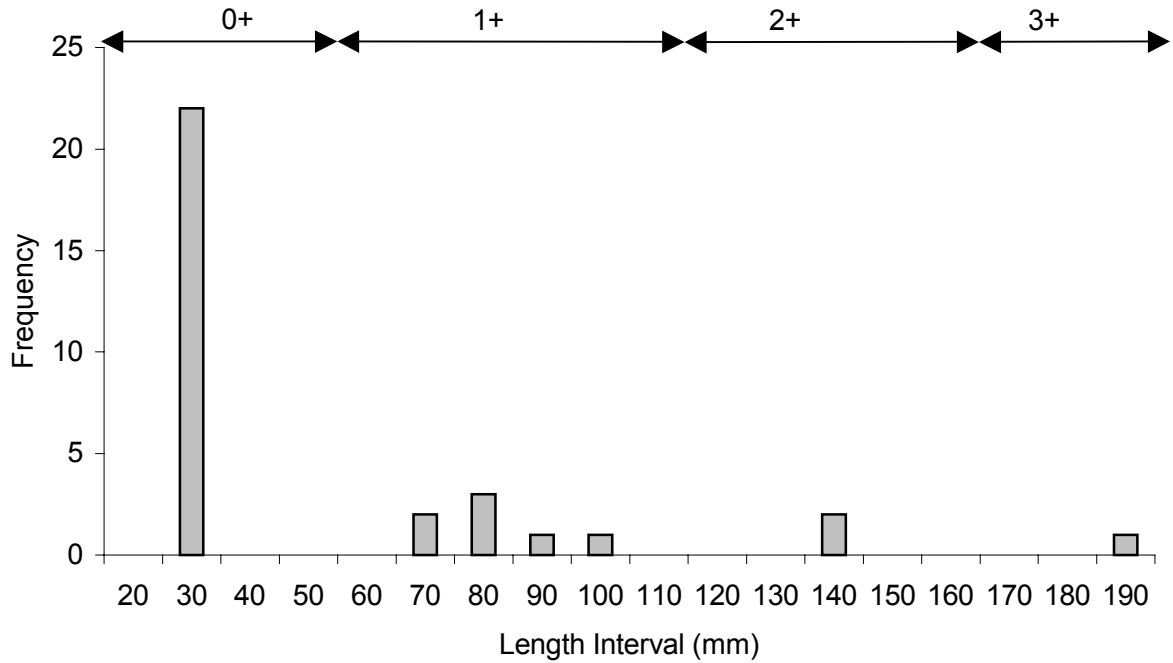


Figure 3.3. Length frequency distribution and estimated age cohorts for Wigwam River Westslope cutthroat trout juveniles.

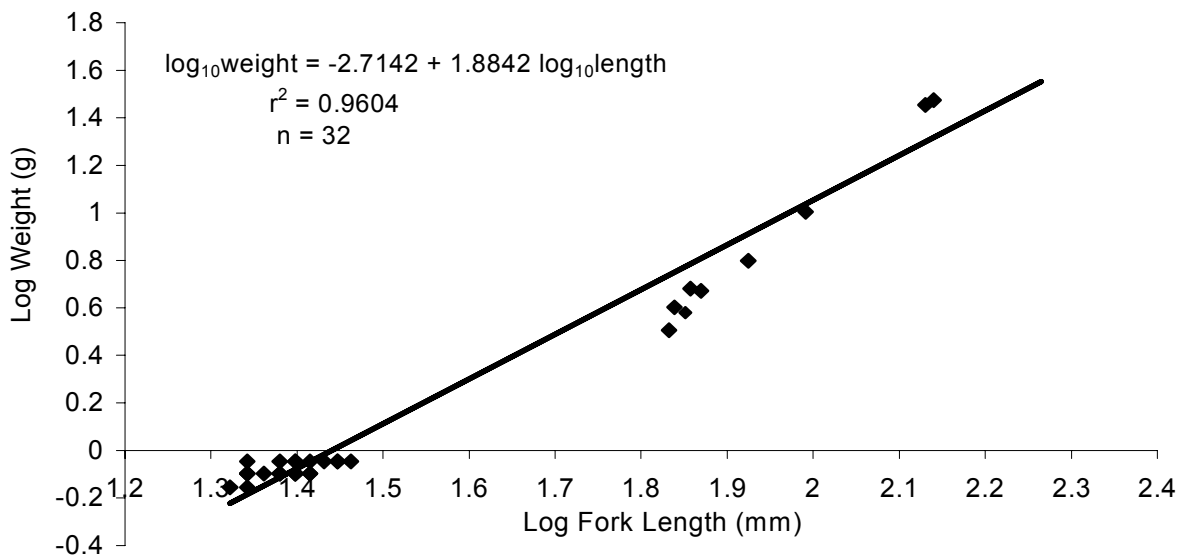


Figure 3.4. Length-weight regression for Westslope cutthroat trout captured within the upper Wigwam River watershed, 9-14 August 2000.

Westslope cutthroat trout captures were not sufficient to generate density estimates (Appendix B). Low densities (mean density = 2.2 fish/100 m²) resulted in low precision (95% confidence interval 1.2 to 17.9 fish/100 m²). This was generally due to either; a non-descending removal pattern, all fish captured in a single pass, or no captures. Maximum likelihood estimation was not possible under these conditions.

3.2 Physical Habitat Monitoring

3.2.1 Water Temperature and Discharge

Discharge estimates within the upper Wigwam River ranged from 0.15 to 3.13 m³/s (Table 3.6). Discharge at the upper Wigwam River hydrometric station (reach five) during fish sampling (9 – 14 August) ranged from 5.20 – 5.78 m³/s (Figure 3.5). The lowest discharge was estimated for reach seven on the 29 September. This site was dewatered on 26 November and an aerial reconnaissance flight in January revealed the majority of this reach was dewatered from the upper reach break downstream to the confluence with Brewery Creek (Appendix A). Anecdotal reports have suggested this reach dewatered in low water yield years. This was the first confirmation of this event and was attributed to low annual precipitation, significantly lower water yield over the previous year resulting in decreased groundwater recharge (Prince and Cope 2001). The relationship between river stage at this location and the hydrometric station below the primary spawning grounds are represented in Figure 3.6.

Table 3.6. Summary of water temperature, mean velocity, and discharge measurements for the Wigwam River fish habitat monitoring sites.

Date	Stream	Reach	Site	Discharge (m ³ /s)	Mean Velocity (m/s)	Water Temp. (°C)
20 Sept.	Wigwam	5	1	3.13	0.33	13.2 ^a /8.0 ^b
4 Oct.	Wigwam	6	2	1.80	0.56	11.0 ^a /5.0 ^b
29 Sept.	Wigwam	7	3	0.15	0.08	11.8 ^a /7.0 ^b
27 Sept.	Wigwam	9	4	0.65	0.22	12.4 ^a /5.0 ^b
19 Sept.	Bighorn	1	1	0.36	0.13	7.0 ^a /7.0 ^b

^a – Spot water temperature during electrofishing (August 9 – 14).

^b – Spot water temperature during habitat survey (Sept 19 – Oct. 4).

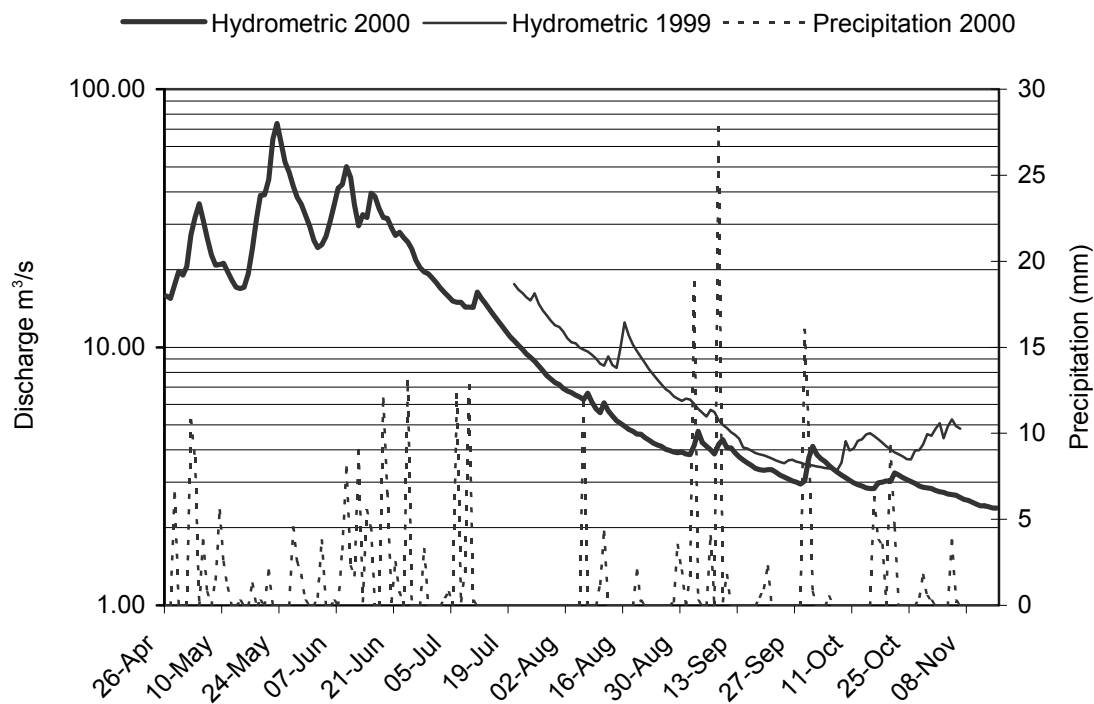


Figure 3.5. Mean daily discharge and total precipitation at the hydrometric station (Reach 5 EMS No. E238242) in 1999 and 2000 (Prince and Cope 2001).

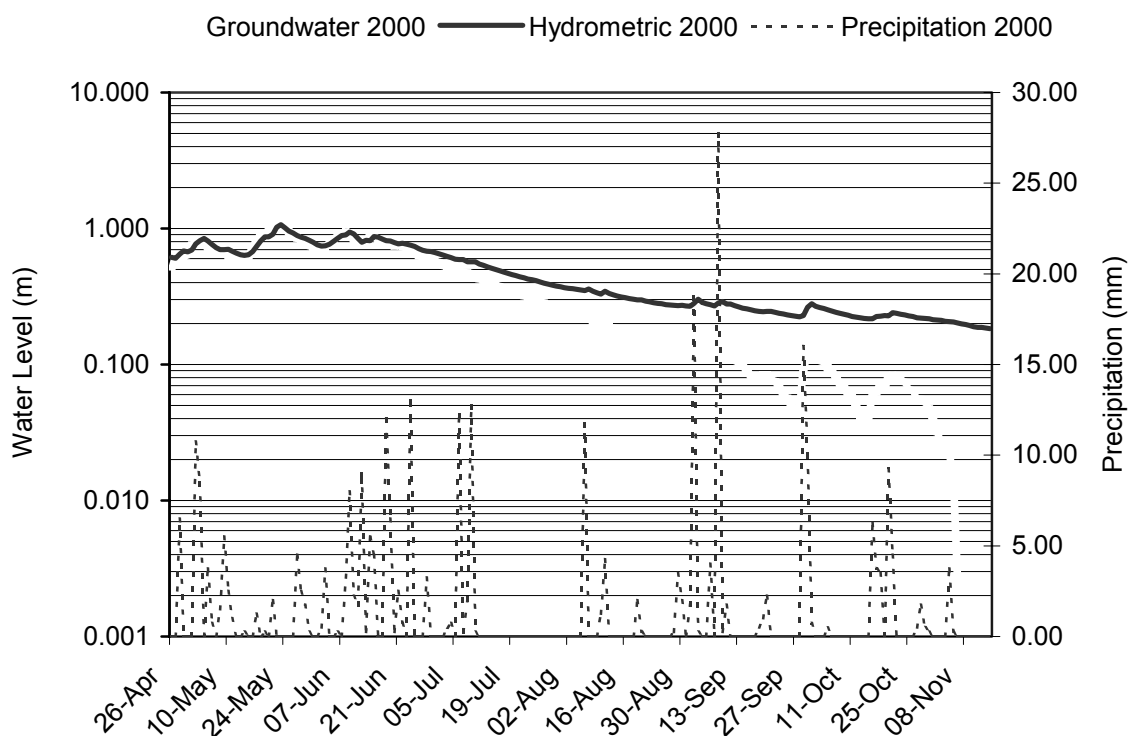


Figure 3.6. Mean daily water levels recorded at the hydrometric station and groundwater station (Reach 7, EMS No. 238246), 2000 (Prince and Cope 2001).

Spot temperatures during sampling were well within bull trout tolerance limits ($<18^{\circ}\text{C}$) and in general, were indicative of cold perennial springs preferred by bull trout ($<12^{\circ}\text{C}$). In 2000, the maximum annual water temperature recorded was 12.2°C in reach seven and 14.3°C in reach five (Figure 3.7). Furthermore, the inverted temperature profile across seasons between upper and lower temperature monitoring locations further demonstrates the influence of groundwater and/or sub-surficial streambed flow in maintaining preferred bull trout spawning and incubation temperatures.

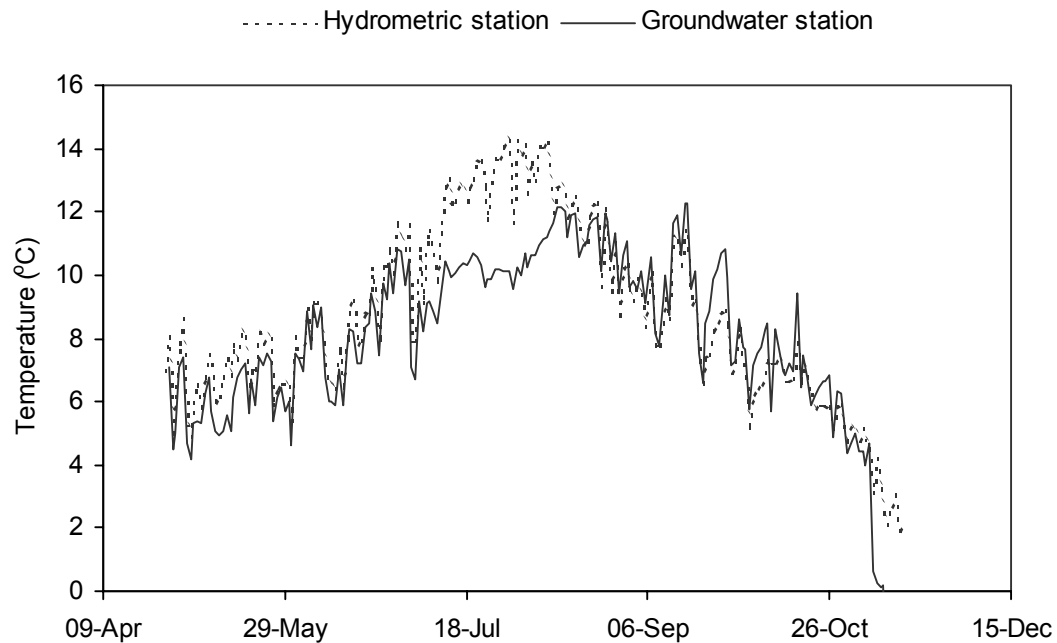


Figure 3.7. Daily maximum water temperatures recorded at the hydrometric station (Reach 5, EMS No. E238242) and the groundwater station (Reach 7, EMS No. 238246), 2000 (Prince and Cope 2001).

3.1.2 Substrate Pebble Counts

The preferred spawning reaches (Wigwam River reach five, six and reach one of Bighorn) were dominated by small cobble and large gravel substrate ranging in particle size from 32 mm to 96 mm (Table 3.7). Reach seven was dominated by large cobble and reach nine was dominated by small boulder.

Table 3.7 Summary of substrate pebble counts (mode, D50, D90) for the Wigwam River fish habitat monitoring sites.

Stream	Reach	Site	Mode (Particle Class mm)	D ₅₀ (Particle class mm)	D ₉₀ (Particle class mm)
Wigwam	5	1	64 – 96	64 – 96	256 – 384
Wigwam	6	2	64 – 96	48 – 64	128 – 192
Wigwam	7	3	128 – 192	64 – 96	192 – 256
Wigwam	9	4	256 – 384	192 – 256	512 – 1024
Bighorn	1	1	32 – 48	32 - 48	64 - 96

3.2.3 Fish Habitat Survey (FHAP Form 4)

The level 1 fish habitat assessment is a purposive field survey of current habitat conditions for the target species in select reaches. In this study, the level 1 FHAP Form 4 was completed for the representative sample sites (two meander wavelengths) within the selected reaches. The output of the WRP data reporting tool are presented in Appendix C and have been archived for long-term trend monitoring. Generic diagnostic data have been summarized as descriptors of present habitat condition (Table 3.8). Note that regional criteria for habitat conditions do not exist and current WRP diagnostic criteria to evaluate habitat condition are exclusive of bull trout and Westslope cutthroat trout data.

Notwithstanding these limitations, diagnostic data clearly indicate the high quality spawning and rearing habitat ratings for reach six of the Wigwam River and reach one of Bighorn Creek. These reaches demonstrate the importance of LWD and it's relationship to habitat diversity and substrate storage and diversity. Reach five pool habitat features were under-represented by site-selection bias for juvenile bull trout and the limitation of two meander wavelengths (400 m) to accurately represent 10.4 km of stream channel. Reaches seven and nine of the Wigwam River were accurately represented as more confined, higher energy reaches with lower habitat diversity. A brief reach and site summary follows for each representative fish and fish habitat sample site. Photo-documentation has also been recorded on standard MOE forms and submitted under separate cover.

Table 3.8. Diagnostics of salmonid habitat condition at the reach level (from Johnston and Slaney 1996). Note that the individual cell format represents value/rating.

	Habitat Parameter											
	Pool % (by area)	Pool Frequency (mean spacing)	LWD Pieces per Bankfull Channel Width	% Wood Cover in Pools	% Boulder Cover in Riffles	% Overhead Cover	Substrate Rearing Habitat (interstitial rating)	Off- Channel Habitat (3% gradient)	Holding Pools (1 m deep, good cover)	Spawning Gravel Quantity	Spawning Gravel Quality	Redd Scour Potential
Reach 5 Wigwam R.	0 P	0 P	5.9 G	N/a	< 10 P	< 10 P	Clear G	Some F	Adequate G	Extensive G	Suitable G	Low G
Reach 6 Wigwam R.	28.2 F	1.2 G	58.3 G	30 G	< 10 P	< 10 P	Clear G	Extensive G	Adequate G	Extensive G	Suitable G	Low G
Reach 7 Wigwam R.	11.5 P	9.7 P	2.67 G	10 F	< 10 P	< 10 P	Clear G	Some F	Few P	Limited P	Suitable G	Fair F
Reach 9 Wigwam R.	0.0 P	0.0 P	2.01 G	N/a	30 G	< 10 P	Clear G	Absent P	Few P	Absent P	Absent P	Extensive P
Reach 1 Bighorn Cr.	35.2 G	4.8 P	3.61 G	20 F	< 10 P	< 10 P	Clear G	Extensive G	Few P	Extensive G	Suitable G	Potential F

Note: regional standards are not available and diagnostic ratings (G – good, F – fair, P – poor) are generalized ratings from Johnston and Slaney (1996) for streams with a bankfull channel width of less than 15 m.

Note: two representative meander lengths were surveyed, not the entire reach.

Wigwam River Reach 5 Site 1

Reach five (length = 10.4 km) was an occasionally confined, irregularly wandering, riffle-pool stream channel. Bankfull channel width varies between 30 and 75 m. Maximum residual pool depth was 2.5 m and pools were associated with LWD accumulations along stream margins and/or valley wall confinement. Riffles and low gradient glides (run) were the dominant habitat. Gradient was 1.0%, bed materials were dominated by small cobble and stream morphology classification was a C3 Rosgen channel type.

Rearing habitat was rated as moderate to good. Boulder, LWD, and side-channel habitat in conjunction with shallow, low velocity, cobble stream margin habitat result in abundant rearing opportunities for all age classes of juvenile trout and char. Spawning habitat was fair to good with sections of excellent spawning gravels present. Fourteen bull trout redds were observed within the two meander wavelengths. Large numbers of Westslope cutthroat trout fry were observed in isolated side-channel habitat.



Figure 3.8. Representative habitat within permanent sample site one, reach five, Wigwam River.

Wigwam River Reach 6 Site 2

Reach six (length = 5.7 km) was an occasionally confined, irregularly meandering, riffle-pool stream channel characterized as an area of sediment storage within a broad alluvial floodplain largely controlled by bedrock outcrops immediately downstream. Lateral instability was indicated by abandoned channels, anastomosing island pattern, eroding banks and extensive, elevated bars. Bankfull channel width varies between 55 and 150 m. Maximum residual pool depth was 1.2 m and pools were associated with LWD accumulations. Gradient was 0.6%, bed materials were dominated by large gravels and small cobble, and stream morphology classification was a D4 channel type.

Rearing habitat was rated as good (LWD, and shallow, low velocity, cobble stream margin fry holding habitat) with excellent side-channel habitat resulting in abundant rearing opportunities for all age classes of juvenile trout and char. The aggraded nature of this reach has resulted in a braided channel comprised of sorted gravels and small cobbles that provide prime spawning habitat. Extensive groundwater exfiltration maintains base winter flows and incubating embryos. Within the sample site, 21 bull trout redds were observed.



Figure 3.9. Downstream aerial view of permanent stream survey site two, reach six, Wigwam River. Note that this location consistently represents the highest densities of bull trout redds and has extensive groundwater exfiltration.

Wigwam River Reach 7 Site 3

Reach seven (length = 2.3 km) was a more confined, irregularly wandering, riffle-pool stream channel. Bankfull channel width varies between 21 and 114 m. Maximum residual pool depth was 1.0 m and pools were associated with channel confinement features and LWD accumulations along stream margins. Riffle and low gradient glide (run) habitat was dominant. Gradient was 0.9%, bed materials were dominated by large cobble, and stream morphology classification was a C3 channel type.

Rearing habitat was rated as good (fry) with excellent juvenile boulder habitat present. Spawning habitat was limited to isolated tail-out habitat. Surficial flow was extremely limited by 29 September (Table 3.6) and by 15 November the entire reach was dewatered and frozen to some depth within the substrate. This reach has been reported to dewater during dry years and years with little fall precipitation. Although no redds were observed, redds have been observed at this location in previous years.



Figure 3.10. Downstream view of representative habitat within permanent stream survey site three, reach seven, Wigwam River. Note that this location dewatered 15 November.

Wigwam River Reach 9 Site 4

Site four was representative of the Canadian portion of the Wigwam River above the focal forest development area. Reach nine (length = 3.4 km) was a confined, sinuous, cascade-pool stream channel dominated by boulder substrate. Bankfull channel width varies between 14 and 24 m. Maximum residual pool depth was 0.6 m and pools were typically boulder plunge pools. The gradient was 2.8% and the Rosgen stream classification was B2. Such systems are stable and contribute only small quantities of sediment.

Fry rearing habitat and spawning habitat was very limited due to the large substrate particle size. Boulder dominated substrate however, provides excellent juvenile rearing habitat and an abundance of boulder pocket pools and velocity refuge.



Figure 3.11. Downstream view of representative habitat within permanent stream survey site four, reach nine, Wigwam River.

Bighorn Creek Reach 1 Site 1

Reach one (length = 1.3 km) was characterized as a sinuous, riffle-pool stream channel within a broad alluvial fan. Several side-channels and groundwater sources were documented within the floodplain. Bankfull channel width varies between 13 and 37 m and maximum residual pool depth was 1.2 m. Pools were associated with channel confinement features and LWD accumulations. This reach was moderately aggraded and disturbance features of note included sediment wedges, extensive unvegetated bars and lateral instability. The gradient was 0.4% and stream morphology was classified as a Rosgen C4 channel type.

Rearing habitat was rated as good (LWD, and shallow, low velocity, cobble stream margin fry holding habitat) with excellent side-channel habitat resulting in abundant rearing opportunities for all age classes of juvenile trout and char. The aggraded nature of this reach has resulted in multiple channels comprised of sorted gravels and small cobbles that provide prime spawning habitat. Extensive groundwater exfiltration maintains base winter flows and incubating embryos. Within the representative sample site, 17 bull trout redds were observed.



Figure 3.12. Downstream view of representative habitat within permanent stream survey site one, reach one, Bighorn creek.

3.1.4 Channel Survey

At 10 m intervals, following the thalweg of the stream channel, the elevation of the stream bed was surveyed over a total of 2,213 m. Elevations of the water surface, streambed (thalweg) and bankfull channel height are illustrated in Appendix D. Table 3.9 summarizes key geomorphic channel features for the select reaches. Longitudinal distance of two meander wavelengths ranged from 265 to 670 m. Results of the differential closed loop within each survey site demonstrate precision levels of between 0.7 to 9 mm per 100 lineal meters (Table 3.8).

In total, 10 channel cross-sections were completed to represent the cross-sectional floodplain profile of representative riffle and pool habitat units within each reach (Appendix D). Bankfull channel width and depth of riffle cross-sections ranged between 13 to 67 m and 0.82 to 1.29 m, respectively (Table 3.9). Mean riffle water depth was 0.196 m. Bankfull channel width and depth of pool cross-sections ranged between 14 to 114m and 1.00 to 2.61m, respectively (Table 3.9). The mean maximum pool water depth was 1.002 m.

Table 3.9. Summary of longitudinal and cross-sectional surveys. Note that the individual cell format represents riffle/pool values.

	Length Surveyed (m)	Differential Loop Survey Error (m)	Elevation Start (m)	Elevation End (m)	Mean Gradient (%)	Mean Thalweg Water Depth (m)	Bankfull Channel Width (m)	Wetted Channel Width (m)	Bankfull Depth (m)	Mean Water Depth (m)	Maximum Water Depth (m)
Reach 5 Wigwam R.	400	-0.015	1117.8	1113.7	1.02	0.57	47.0	22.1	1.23	0.27	0.48
							63.3	36.7	1.87	0.37	0.94
Reach 6 Wigwam R.	670	+0.013	1196.8	1192.5	0.64	0.57	66.6	16.2	0.86	0.15	0.33
							83.6	12.7	2.61	1.20	2.04
Reach 7 Wigwam R.	590	-0.023	1237.2	1232.0	0.88	0.28	33.4	14.2	1.29	0.13	0.28
							114.1	8.3	1.56	0.47	0.78
Reach 9 Wigwam R.	288	+0.002	1328.2	1321.7	2.80	0.44	13.0	10.2	1.09	0.32	0.46
							15.0	11.1	1.00	0.32	0.57
Reach 1 Bighorn Cr.	265	-0.023	1121.9	1119.3	0.38	0.44	36.2	8.6	0.82	0.11	0.24
							14.0	8.3	1.23	0.37	0.68

4 Discussion

Five permanent sampling sites were established in the Wigwam river drainage (one site on Bighorn Creek and four sites on the mainstem Wigwam River). The 2000 project year represents the first year of a long-term bull trout monitoring program and current studies focused on establishing permanent representative sample sites and collecting baseline information. Forest development within the Canadian portion of the upper Wigwam River commenced in August 1997 (road development). The first cut-blocks are scheduled to be harvested in the winter of 2000/2001.

Relative to co-existing species, bull trout densities usually are low, and most broad faunal surveys indicate less than 5% of the total catch is made up of bull trout (McPhail and Baxter 1996, Reiman and McIntyre 1995). However, in the upper Wigwam River, bull trout represented 92.4% of the catch and the mean density of all juvenile bull trout was estimated to be 17.2 fish/100m² (range 0 to 26.9 fish/100m²). Fry dominated the catch and this was a direct result of juvenile bull trout ecology and habitat partitioning among life history stages. Site selection was biased towards electrofishing sample sites which favored high bull trout fry capture success.

Areas with juvenile bull trout densities greater than 1.5 fish/100m² have been cited as critical rearing areas (Goetz 1989), and previously reported juvenile densities within the upper Wigwam River are some of the highest recorded (Cope 1998). Comparison of fry density estimates replicated across both the preliminary survey (Cope 1998) and the current study illustrate the stable nature of these high densities (Table 4.1). To eliminate spatial and sampler bias, the identical habitat units were sampled within reaches five and seven using the same personnel and methods.

Table 4.1. Comparative bull trout fry density estimates for 1997 and 2000 surveys.

	Density Estimate (mean +/- 95% confidence Interval)	
	1997	2000
Reach 5	15.6 (13.5 – 18.6)	17.1 (14.7 – 19.8)
Reach 7	16.8 (14.8 – 18.9)	16.4 (16.0 – 17.3)

When compared to other bull trout systems, the large spawning escapement (Baxter and Westover 2000) and high juvenile densities provide a strong case that the Wigwam River may be the most prolific bull trout population in the species distributional range. At the very least, it can be concluded that the pre-forest harvesting population of upper Wigwam River bull trout represent a large and stable population with high juvenile bull trout densities. Bull trout populations have been shown to be extremely susceptible to habitat degradation and overharvest (McPhail and Baxter 1996, Ratliff et al. 1996) and are ecologically important as an indicator of watershed health (Baxter 1997). As such, the upper Wigwam River watershed remains relatively pristine, and maintains high water quality (Prince and Cope 2001), high habitat capability (Oliver and Cope 1999) and, conservative angling regulations have been successful in preventing over-exploitation (Baxter and Westover 2000).

A rain-on-snow event occurred in mid-November 1999 and there was some concern regarding redd scour and the potential negative impacts to fry recruitment (H. Tepper, MOE, Cranbrook, B.C., *pers. comm.*). This event was considered to be close to bankfull discharge. Results of the fry enumeration suggest a fall storm of this magnitude (*i.e.* within bankfull height) and duration (24 hours) was not detrimental to incubating bull trout embryos. In contrast, the worse case low water scenario would be no snow cover, no fall rains and an early freeze and dewatering of side-channel and mainstem incubation and fry habitat. This was exactly what happened in the fall of 2000 and the water yield was significantly lower than in 1999 (Prince and Cope 2001). The significant difference in hydraulic conditions will provide an interesting contrast for proposed sampling in August 2001.

Maximum summer water temperatures of 14 – 18°C appear to limit bull trout distribution (Baxter and McPhail 1996). In 2000, the maximum annual water temperature recorded was 12.2 °C in reach seven and 14.3 °C in reach five. Furthermore, the inverted temperature profile across seasons between upper and lower temperature monitoring locations further demonstrates the influence of groundwater and/or sub-surface streambed flow in maintaining preferred bull trout spawning and incubation temperatures within the upper Wigwam River valley (Prince and Cope 2001). Any increase in water temperature and/or decrease in groundwater could result in limitations to juvenile bull trout distribution.

Trends in abundance appeared to be related to proximity to spawning areas, bed material size, water depth and LWD. The association of bull trout fry with shallow (5 – 20 cm), low velocity (<0.3 m/s), cobble dominated stream margin habitat has been previously

documented within the Wigwam River (Cope 1998). The upper Wigwam River is comprised of sorted gravels and small cobbles with a very low percentage of fines that provide prime spawning and rearing habitat. Extensive groundwater and sub-surface streambed exfiltration maintains water temperatures and base winter flows.

In total, 2,213 m of stream channel was longitudinal surveyed and 10 representative cross-sections were surveyed. The error term associated with the morphological survey was between 0.7 and 9 mm per 100 m; thus the survey data can meet precision levels to determine if site-specific impacts are occurring. The range of morphological stream types (B2, C3, C4, D4) encompass the depositional (aggrading) to degrading and sensitive to resilient spectrum and vary from very low to very high bedload sediment yields.

A number of site-specific disturbance features of note included sediment wedges, extensive unvegetated bars and lateral instability. Aerial photographs (35 mm) within reach six dating to the late 1970's (G. Oliver, Cranbrook, B.C., *pers. comm.*) demonstrate remarkable similarity to Figure 3.10. Although reach six appears to be aggrading these photographs suggest stability. This was in spite of the 1995 rain-on-snow event generally believed to represent a 1 in 150 year flood event. Minor shifting of braids and some down-cutting has occurred since 1995 but no major change in geo-morphology or bed material size class has occurred since the late 1970's. These observations suggest the D4 stream channel of the prime bull trout spawning grounds, although a very high sediment storage and bedload yield reach is currently in equilibrium and should be considered very sensitive. The diagnostics summary table (Table 3.7) demonstrates the importance of LWD to stream structure and sediment storage, habitat diversity, and stability within this reach.

5 References

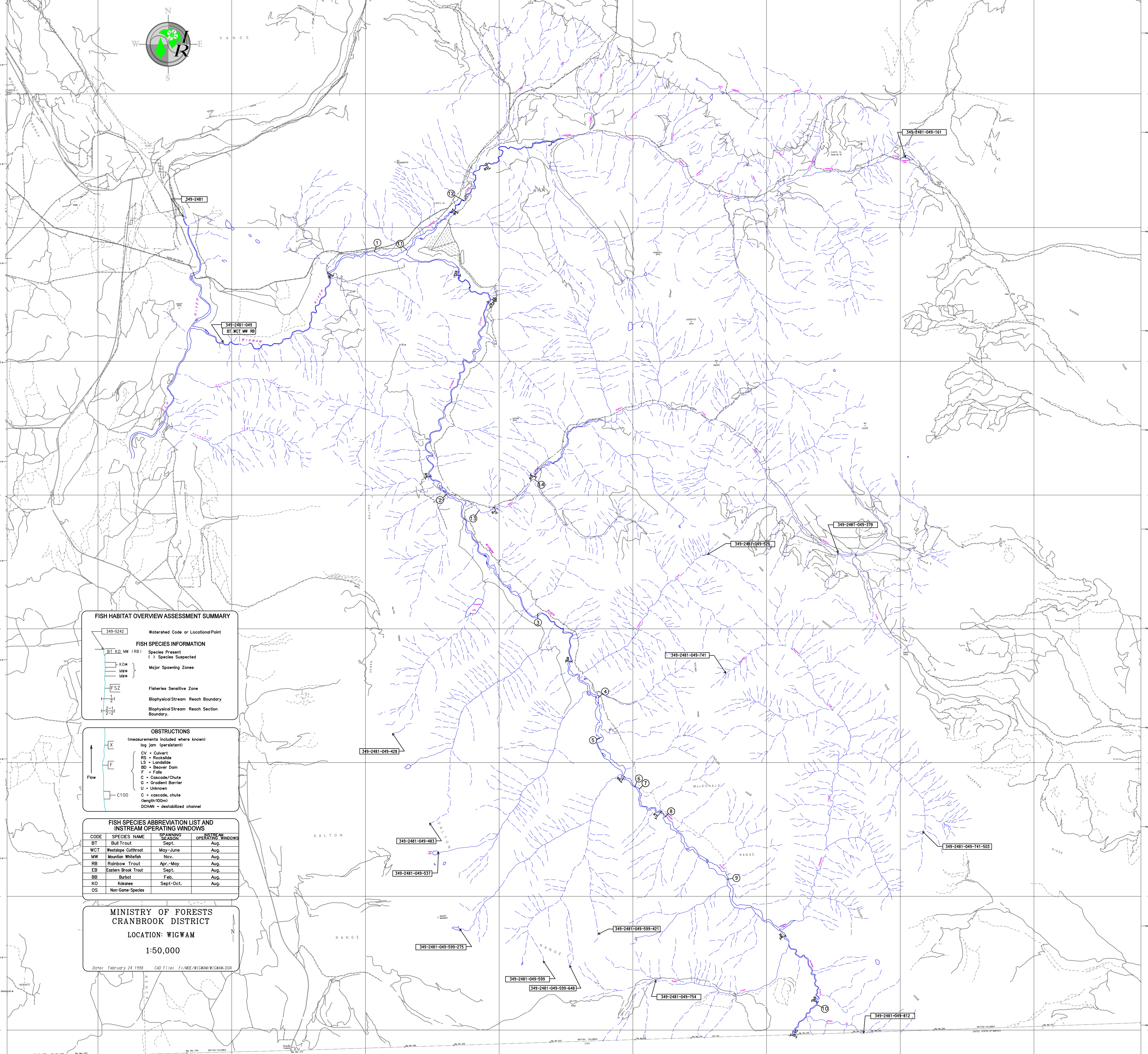
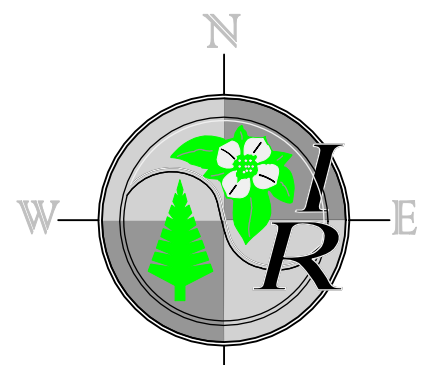
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Appendix A

1:50,000 TRIM Map



FISH HABITAT OVERVIEW ASSESSMENT SUMMARY

349-5242 Watershed Code or Locational Point

FISH SPECIES INFORMATION

BT KO MW (RB) Species Present
() Species Suspected

Major Spawning Zones

FSZ Fisheries Sensitive Zone

Biophysical Stream Reach Boundary

Biophysical Stream Reach Section Boundary

OBSTRUCTIONS
(measurements included where known)
log jam (persistent)

Flow

CV - Culvert
RS - Rockslide
LS - Landslide
BD - Beaver Dam
F - Falls
C - Cascade/Chute
G - Gradient Barrier
U - Unknown
C - cascade, chute (length=100m)
DOHAN - destabilized channel

FISH SPECIES ABBREVIATION LIST AND INSTREAM OPERATING WINDOWS			
CODE	SPECIES NAME	SPAWNING SEASON	INSTREAM OPERATING WINDOWS
BT	Bull Trout	Sept.	Aug.
WCT	Westslope Cutthroat	May-June	Aug.
MW	Mountain Whitefish	Nov.	Aug.
RB	Rainbow Trout	Apr.-May	Aug.
EB	Eastern Brook Trout	Sept.	Aug.
BB	Burbot	Feb.	Aug.
KO	Kokanee	Sept-Oct.	Aug.
OS	Non-Game Species		

**MINISTRY OF FORESTS
CRANBROOK DISTRICT**

LOCATION: WIGWAM

1:50,000

Date: February 24 1998 CAD File: F:\MOE\WIGWAM\WIGWAM.DGN

Appendix B

Fish Capture Data

Table B1. Summary of electroshocking sample effort and catch in the Wigwam River and Bighorn Creek, 9 to 14 August 2000.

Reach No.	Site No.	Haul No.	Sample Effort		Catch (number of fish)				Total Catch
			Time (s)	Area m2	BT ¹ fry ³	WCT ² fry ³	BT ¹ juv. ⁴	WCT ² juv. ⁴	
1 ^a	1	1	1330	254.7	13	1			14
1 ^a	1	2	1150	254.7	9	1			10
1 ^a	1	3	1230	254.7	6	3			9
1 ^a	2	1	678	238.2	10				10
1 ^a	2	2	655	238.2	8				8
1 ^a	2	3	570	238.2	6				6
SUBTOTAL		1	2008	492.9	23	1	0	0	24
		2	1805	492.9	17	1	0	0	18
		3	1800	492.9	12	3	0	0	15
TOTAL			5613	492.9	52	5	0	0	57
5	1	1	1378	193.93	15			2	17
5	1	2	1072	193.93	12		1	4	17
5	1	3	981	193.93	9				9
5	2	1	1802	265.68	26	2			28
5	2	2	1695	265.68	9	4			13
5	2	3	1083	265.68	4	2			6
5	3	1	1043	138.24	8				8
5	3	2	603	138.24	3				3
5	3	3	593	138.24	2				2
SUBTOTAL		1	4223	597.85	49	2	0	2	53
		2	3370	597.85	24	4	1	4	33
		3	2657	597.85	15	2	0	0	17
TOTAL			10250	597.85	88	8	1	6	103
6	1	1	1328	180	22	1			23
6	1	2	1005	180	14				14
6	1	3	1105	180	13	1			14
6	2	1	1498	180	19	3			22
6	2	2	1093	180	7	1			8
6	2	3	1007	180	5				5
6	3	1	1932	150	27	2	2	1	32
6	3	2	985	150	10	1			11
6	3	3	714	150	2	1	1		4
SUBTOTAL		1	4758	510	68	6	2	1	77
		2	3083	510	31	2	0	0	33
		3	2826	510	20	2	1	0	23
TOTAL			10667	510	119	10	3	1	133

^a Bighorn Creek

Cont...

¹ Bull Trout

² Westslope Cutthroat Trout

³ 0+ age group

⁴ 1+, 2+, 3+ age groups combined

Table B1. Contd.

Reach No.	Site No.	Haul No.	Sample Effort		Catch (number of fish)				Total Catch
			Time (s)	Area m2	BT ¹ fry ³	WCT ² fry ³	BT ¹ juv. ⁴	WCT ² juv. ⁴	
7	1	1	1807	203	28				28
7	1	2	1178	203	5				5
7	1	3	1086	203	1				1
7	2	1	909	185.25	11				11
7	2	2	807	185.25	4				4
7	2	3	619	185.25	2				2
7	3	1	819	111	18				18
7	3	2	708	111	7				7
7	3	3	554	111	4				4
SUBTOTAL		1	3535	499.25	57	0	0	0	57
		2	2693	499.25	16	0	0	0	16
		3	2259	499.25	7	0	0	0	7
TOTAL			8487	499.25	80	0	0	0	80
9	1	1	1213	239.44	8			1	9
9	1	2	818	239.44	6				6
9	1	3	776	239.44					0
9	2	1	535	150	2			1	3
9	2	2	450	150	1				1
9	2	3	414	150				1	1
9	3	1	848	109.62	13				13
9	3	2	758	109.62	10				10
9	3	3	625	109.62	3				3
SUBTOTAL		1	2596	499.06	23	0	0	2	25
		2	2026	499.06	17	0	0	0	17
		3	1815	499.06	3	0	0	1	4
TOTAL			4622	499.06	43	0	0	3	46
GRAND TOTAL			39639	2599.06	382	23	4	10	419

^a Bighorn Creek¹ Bull Trout² Westslope Cutthroat Trout³ 0+ age group⁴ 1+, 2+, 3+ age groups combined

Table B2. Summary of site population estimates and density estimates for bull trout (BT) within the Wigwam River study area, 9 to 14 August, 2000. Note that three pass removal-depletion method was used to estimate abundance (see catch summary).

Life Stage	Site Estimate						
	Population Estimate (No. of Fish)	Low 95% Confidence Interval (No. of Fish)	High 95% Confidence Interval (No. of Fish)	Density Estimate (No./100m ²)	Low 95% Confidence Interval (No./100m ²)	High 95% Confidence Interval (No./100m ²)	Capture Probability
Wigwam River, Reach 5, Site 1 (597.85 m ²)							
BT Fry	102	88	118.65	17.1	14.7	19.8	0.478
BT Juv.	0	0	0	0	0	0	0
Wigwam River, Reach 6, Site 2 (510.00 m ²)							
BT Fry	137	119	155.27	26.9	23.3	30.4	0.488
BT Juv.	3	3	6.05	0.6	0.6	6	0.6
Wigwam River, Reach 7, Site 3 (499.25 m ²)							
BT Fry	82	80	86.22	16.4	16	17.3	0.690
BT Juv.	0	0	0	0	0	0	0
Wigwam River, Reach 9, Site 4 (499.06 m ²)							
BT Fry	46	43	52.54	9.2	8.6	10.5	0.573
BT Juv.	0	0	0	0	0	0	0
Bighorn Creek, Reach 1, Site 1 (492.90 m ²)							
BT Fry	77	52	118.64	15.6	10.5	24.1	0.310
BT Juv.	0	0	0	0	0	0	0
Mean Densities							
BT Fry				17.0	14.6	20.4	
BT Juv.				0.1	0.1	1.2	
Combined				17.2	14.7	21.6	

Table B3. Summary of site population estimates and density estimates for Westslope cutthroat trout (WCT) within the Wigwam River study area, 9 to 14 August, 2000. Note that three pass removal-depletion method was used to estimate abundance (see catch summary).

Life Stage	Site Estimate						
	Population Estimate (No. of Fish)	Low 95% Confidence Interval (No. of Fish)	High 95% Confidence Interval (No. of Fish)	Density Estimate (No./100m ²)	Low 95% Confidence Interval (No./100m ²)	High 95% Confidence Interval (No./100m ²)	Capture Probability
Wigwam River, Reach 5, Site 1 (597.85 m ²)							
WCT Fry	13	8	40.28	2.2	1.3	6.74	0.258
WCT Juv.	6	6	8.58	1	1	1.44	0.600
Wigwam River, Reach 6, Site 2 (510.00 m ²)							
WCT Fry	10	10	12.52	2	2	2.45	0.625
WCT Juv.	0	0	0	0	0	0	0
Wigwam River, Reach 7, Site 3 (499.25 m ²)							
WCT Fry	0	0	0	0	0	0	0
WCT Juv.	0	0	0	0	0	0	0
Wigwam River, Reach 9, Site 4 (499.06 m ²)							
WCT Fry	0	0	0	0	0	0	0
WCT Juv.	3	3	6.05	0.6	0.6	1.21	0.600
Bighorn Creek, Reach 1, Site 1 (492.90 m ²)							
WCT Fry	25	5	383.15	5.07	1	77.73	0.069
WCT Juv.	0	0	0	0	0	0	0
Mean Densities							
WCT Fry				1.9	0.9	17.4	
WCT Juv.				0.3	0.3	0.5	
Combined				2.2	1.2	17.9	

Appendix C

FHAP Level 1 Form 4 Data

Level 1 - Habitat Summary Diagnosis Rep

Form Number	Forest District: CRANBROOK	
1	Watershed Name: BIGHORN CREEK	
Watershed Code: 349-248100-04900-37900-0000-0000-000-000-000-000		
Survey Date:	9/19/2000	Weather: cloudy, scattered showers
Discharge:	0.358	(cubic meters per second)
Survey Crew: SC/KM/AP		
Subsampling Fractions:		
Riffles	1 in 1	Pools 1 in 1
Glides	1 in 1	Cascades 1 in 1
Other		
TS Maps (1:50,000) 082G02		
BGS Maps (1:20,000) 082G016		

Detail No	Sub Basin Name	Reach No	Section No	UTM			Distance (m)	Habitat Unit		Length (m)	Gradient (%)	Mean Depth		Mean Width		Pools Only			
				Zone	Easting	Northing		Type	Cat			Bankfull (m)	Water (m)	Bankfull (m)	Wetted (m)	Max Depth (m)	Crest (m)	Residual (m)	Pool Type
1	BIGHORN CREEK	1	1	11	649089	5449439	539	R	1	59	0.38	0.8	0.28	17	5.4				

Comments :

1 BT redd, cross section location

2	BIGHORN CREEK	1	1	11	649102	5449417	539	R	2	59	0.38	0.6	0.13	12.8	4.5				
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Comments :

EF site

3	BIGHORN CREEK	1	1	11			565	P	1	26	0.38	1.2	0.84	14.8	8.1	0.92	0.14	0.68	S
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Comments :

3 BT redds

4	BIGHORN CREEK	1	1	11	649147	5449472	588	P	1	23	0.38	1.8	0.99	20.5	10.5	1.1	0.15	0.95	S
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Comments :

4 BT redds

5	BIGHORN CREEK	1	1	11			628	P	1	40	0.38	1.95	1.05	28.3	9.4	1.2	0.21	0.99	D
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Comments :

2 BT redds

Form Number
1

Bed Material Type						Total LWD Tall	Functional LWD			Cover				Offchannel Habitat			Disturbance Indicators			Riparian Vegetation			Barriers
Dom.	Sub-Dom.	D90 (mm)	Compaction	SG Type	SG Amt		10 - 20 mm	20 - 50 mm	>50mm	Cover Type 1	%	Cover Type 2	%	Type	Access	Length (m)	1	2	3	Type	Structure	Canopy Closure	
C	G	80	M	R	L	3	3			B	2	LWD	5	SC	G	80	DW	MB	EB	M	MF	1	N

G	C	60	M	R	L	5	4	1		LWD	5			SC	G	80	DW	MB	EB	M	PS	1	N
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S	G	10	M	R	L	5	5			LWD	20	DP	30				EB	PD		M	PS	1	N
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G	S	20	M	R	H	5	3	2		LWD	10	DP	60	SC	G	300	EB	WG		M	PS	1	N
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G	S	20	M	R	H	21	15	5	1	LWD	30	SWD	40				WG	JM	EB	M	MF	1	N
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Level 1 - Habitat Summary Diagnosis Rep

6	HIGHORN CREEK	1	1	11			686	R	1	58	0.38	0.9	0.39	19.3	3.4				
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Comments :

2 BT redds

7	HIGHORN CREEK	1	1	11	648335	5449685	743	G	1	57	0.38	1.1	0.57	13.7	5.9				
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Comments :

5 BT redds

C	G	80	M	R	H	8	8			C	20	LWD	10	SC	P	50	WG	DW	EB	M	MF	1	N
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G	S	20	M	R	H	5	5			C	10	LWD	10	SC	P	50	DW			M	MF	1	N
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Level 1 - Habitat Summary Diagnosis Rep

Form Number	Forest District: CRANBROOK	
2	Watershed Name: WIGWAM RIVER	
Watershed Code: 349-248100-04900-00000-00000-0000-000-000-000-000-000		
Survey Date: 9/21/2000	Weather: cloudy with flurries	Survey Crew: AP/KM/SC
Discharge: 3.128	(cubic meters per s	
Subsampling Fractions:		
Riffles 1 in 1	Pools 1 in 1	Glides 1 in 1
Cascades 1 in 1	Other	
TS Maps (1:50,000) 082G03		
BGS Maps (1:20,000) 082G016		

Detail No	Sub Basin Name	Reach No	Section No	UTM			Distance (m)	Habitat Unit		Length (m)	Gradient (%)	Mean Depth		Mean Width		Pools Only			
				Zone	Easting	Northing		Type	Cat			Bankfull (m)	Water (m)	Bankfull (m)	Wetted (m)	Max Depth (m)	Crest (m)	Residual (m)	Pool Type
1	WIGWAM RIVER	5	5	11	648335	5449685	0	R	1	52	1.02	1.5	0.43	50.9	23.6				

Comments :

Photos: Roll 62 F4

2	WIGWAM RIVER	5	5	11			52	G	1	108	1.02	1.5	0.82	63.3	24.5				
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Comments :

Photos: Roll 62 F9, 11 BT redds in tail out of glide, more like a pool but did not meet pool c

3	WIGWAM RIVER	5	5	11	648156	5449814	160	R	1	80	1.02	1.2	0.45	47	22.1				
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Comments :

Riffle cross section location, refer to for photos

4	WIGWAM RIVER	5	5	11			220	G	1	120	1.02	1.15	0.7	36.3	22				
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Comments :

3 BT redds, 5% LWD and 5% cutbank cover, Photos: Roll 62 F11, more like a pool but did not mee

5	WIGWAM RIVER	5	5	11			340	R	1	128	1.02	1.35	0.35	33.1	14.3				
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Comments :

Photos: Roll 62 F12

Form Number
2

Bed Material Type						Total LWD Tall	Functional LWD			Cover				Offchannel Habitat			Disturbance Indicators			Riparian Vegetation			Barrie rs
Dom.	Sub- Dom.	D90 (mm)	Compaction	SG Type	SG Amt		10 - 20 mm	20 - 50 mm	>50mm	Cover Type 1	%	Cover Type 2	%	Type	Access	Length (m)	1	2	3	Type	Structure	Canopy Closure	
C	B	224	M	R	N	20	16	4		B	5			SC	G	120	DW	FP	PD	C	MF	1	N

B	C	240	M	R	H	17	14	3		C	5	SWD	5	SC	P	150	DW	FP		C	MF	1	N
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depth requirements

C	B	224	M	R	N	18	14	4		B	10	SWD	5				EB	SC	DW	C	MF	1	N
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C	B	224	M	R	L	5	5			B	10	DP	10				EB	DW	FP	C	MF	1	N
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at depth requirements

B	C	240	M	R	N	0				B	20						SC	DW		C	MF	1	N
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Level 1 - Habitat Summary Diagnosis Rep

6	WIGWAM RIVER	5	5	11			0	R	2	125	1.02	0.7	0.07	13.9	4.5	0.15	0	0.15	S
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Comments :

Full of YOY WCT, groundwater flowing in channel, Photos: R62 F5-8

7	WIGWAM RIVER	5	5	11	648080	5449780	180	P	2	150	1.02	0.6	0.1	9.5	6.5	0.35	0	0.35	D
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Comments :

Photos: Roll 62 F9 and 10

C	G	80	M	R	L	8	8			B	10	C	10	SC	G	120	SC	PD	FP	C	MF	1	N
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S	S	1	M	R	N	3	2	1		C	20	SWD	10	PD	P	150				C	MF	2	BD
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Level 1 - Habitat Summary Diagnosis Rep

Form Number	Forest District: CRANBROOK	
3	Watershed Name: WIGWAM RIVER	
Watershed Code: 349-248100-04900-00000-00000-0000-000-000-000-000-000		
Survey Date:	10/2/2000	Weather: partly cloudy
Discharge:	0.145	(cubic meters per s
Survey Crew: SC/KM		
Subsampling Fractions:		
Riffles	1 in 1	Pools 1 in 1
Glides	1 in 1	Cascades 1 in 1
Other		
TS Maps (1:50,000) 082G03		
BGS Maps (1:20,000) 082G006		

Detail No	Sub Basin Name	Reach No	Section No	UTM			Distance (m)	Habitat Unit		Length (m)	Gradient (%)	Mean Depth		Mean Width		Pools Only			
				Zone	Easting	Northing		Type	Cat			Bankfull (m)	Water (m)	Bankfull (m)	Wetted (m)	Max Depth (m)	Crest (m)	Residual (m)	Pool Type
1	WIGWAM RIVER	7	7	11	655471	5438625	0	G	1	80	0.88	1.25	0.49	33.1	14.7				

Comments :

Photos: Roll W64 F2-4

2	WIGWAM RIVER	7	7	11	655186	5438950	260	R	1	270	0.88	1.05	0.26	20.9	18.4				
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Comments :

Photos: Roll W64 F5-6

3	WIGWAM RIVER	7	7	11			350	G	1	40	0.88	1.45	0.41	26.1	10.1				
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Comments :

Photos: Roll W63 F24-25

4	WIGWAM RIVER	7	7	11	655250	5438840	390	P	1	30	0.88	1.7	0.82	28.6	6.2	0.9	0.35	0.55	S
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Comments :

Photos: Roll W63 F22-23

5	WIGWAM RIVER	7	7	11			420	R	1	30	0.88	1	0.28	40	9.2				
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Comments :

Photos: Roll W63 F20-21

Form Number
3

Bed Material Type						Total LWD Tall	Functional LWD			Cover				Offchannel Habitat			Disturbance Indicators			Riparian Vegetation			Barriers
Dom.	Sub-Dom.	D90 (mm)	Compaction	SG Type	SG Amt		10 - 20 mm	20 - 50 mm	>50mm	Cover Type 1	%	Cover Type 2	%	Type	Access	Length (m)	1	2	3	Type	Structure	Canopy Closure	
C	B	224	M	R	L	6	6			B	2	LWD	2				DW	EB	WG	M	PS	1	N

C	G	80	M	R	L	25	18	7		B	2						PD	EB		M	PS	1	N
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C	B	224	M	R	L	5	3	2		B	5						EB	PD		C	MF	1	N
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C	G	80	M	R	L	0				B	20	DP	10				EB			C	MF	1	N
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S	C	64	M	R	L	0				B	2			SC	P	30	DW			C	MF	1	N
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Level 1 - Habitat Summary Diagnosis Rep

6	WIGWAM RIVER	7	7	11			440	P	1	20	0.88	1.65	0.89	62	8.15	1.05	0.3	0.65	S
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Comments :

Photos: Roll W63 F8-14

7	WIGWAM RIVER	7	7	11			460	G	1	110	0.88	1.1	0.64	39.2	9.7	0.71	0.22	0.49	
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Comments :

A 60 m pond, unaccessible at all times is present in this section, Photos: Roll W63 F15-17, W64

8	WIGWAM RIVER	7	7	11	654977	5439074	570	R	1	70	0.88	1	0.23	24.9	13.5				
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Comments :

Photos: Roll W63 F18-19

C	G	80	M	R	L	7	6	1		DP	20	LWD	20	SC	P	20	DW	PD		C	MF	1	N
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C	G	80	M	R	H	3	1	2		C	5	SWD	5	SC	P	110	DW	FP		C	MF	1	N
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F1

C	G	80	M	R	L	6	5	1		LWD	5	C	2				DW	FP	PD	C	MF	1	N
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Level 1 - Habitat Summary Diagnosis Rep

Form Number	Forest District: CRANBROOK		
4	Watershed Name: WIGWAM RIVER		
Watershed Code: 349-248100-04900-00000-0000-0000-000-000-000-000-000			
Survey Date:	9/27/2000	Weather:	cloudy, snow flurries,
Discharge:	0.658	(cubic meters per s	
Survey Crew: SC/KM			
Subsampling Fractions:			
Riffles	1 in 1	Pools	1 in 1
Glides	1 in 1	Cascades	1 in 1
Other			
TS Maps (1:50,000)		082G03	
BGS Maps (1:20,000)		082G007	

Detail No	Sub Basin Name	Reach No	Section No	UTM			Distance (m)	Habitat Unit		Length (m)	Gradient (%)	Mean Depth		Mean Width		Pools Only			
				Zone	Easting	Northing		Type	Cat			Bankfull (m)	Water (m)	Bankfull (m)	Wetted (m)	Max Depth (m)	Crest (m)	Residual (m)	Pool Type
1	WIGWAM RIVER	9	9	11	661031	5432738	0	C	2	30	2.8	1.35	0.32	23.7	12.8				

Comments :

No disturbance indicators, stable (Rosgen B channel). Overstream veg cover also. Photos: Rol:

2	WIGWAM RIVER	9	9	11	660942	5432911	0	R	1	80	2.8	0.65	1.12	22.5	21				
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Comments :

Stable channel, no disturbance signs. Overstream veg and LWD cover also present. Photos: Rol:

3	WIGWAM RIVER	9	9	11	660830	5433065	80	C	1	208	2.8	1.1	0.47	14.1	10.65				
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Comments :

Stable channel with no "as defined" pools. Cutbank and overstream veg cover also present. Ph

Form Number

4

Bed Material Type						Total LWD Tall	Functional LWD			Cover				Offchannel Habitat			Disturbance Indicators			Riparian Vegetation			Barriers
Dom.	Sub-Dom.	D90 (mm)	Compaction	SG Type	SG Amt		10 - 20 mm	20 - 50 mm	>50mm	Cover Type 1	%	Cover Type 2	%	Type	Access	Length (m)	1	2	3	Type	Structure	Canopy Closure	
B	C	768	M	R	L	7	5	2		C	5	LWD	2							M	MF	1	N

1 W62 F33-35

C	B	450	M	R	L	5	3	2		B	15	C	5							M	MF	1	N
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1 W62 F36, W63 F1-2

B	C	768	M	R	L	19	11	8		B	40	LWD	5							M	MF	1	N
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otos: Roll W63 F3-4

Level 1 - Habitat Summary Diagnosis Rep

Form Number	Forest District: CRANBROOK	
5	Watershed Name: WIGWAM RIVER	
Watershed Code: 349-248100-04900-00000-0000-0000-000-000-000-000-000		
Survey Date:	10/4/2000	Weather: cloudy with snow flurri
Discharge:	1.795	(cubic meters per s
Survey Crew: KM/SC		
Subsampling Fractions:		
Riffles	1 in 1	Pools 1 in 1
Glides	1 in 1	Cascades 1 in 1
Other		
TS Maps (1:50,000) 082G03		
BGS Maps (1:20,000) 082G006		

Detail No	Sub Basin Name	Reach No	Section No	UTM			Distance (m)	Habitat Unit		Length (m)	Gradient (%)	Mean Depth		Mean Width		Pools Only			
				Zone	Easting	Northing		Type	Cat			Bankfull (m)	Water (m)	Bankfull (m)	Wetted (m)	Max Depth (m)	Crest (m)	Residual (m)	Pool Type
1	WIGWAM RIVER	6	6	11	653886	5441349	0	P	1	60	0.64	2.5	1.9	54	12.7	2	0.3	1.7	S

Comments :

2	WIGWAM RIVER	6	6	11			60	G	1	90	0.64	1.1	0.43	130	13.5				
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Comments :

5 BT redds near top, adjacent to pool, Photos: Roll W64 F23

3	WIGWAM RIVER	6	6	11			150	R	1	70	0.64	1.3	0.42	150	13				
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Comments :

No redds. Photos: Roll W64 F22

4	WIGWAM RIVER	6	6	11			220	P	1	70	0.64	1.2	0.93	130	15.3	1.2	0.4	0.8	S
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Comments :

3 BT redds. Photos: Roll W64 F21

5	WIGWAM RIVER	6	6	11			290	R	1	120	0.64	1.45	0.45	54.9	16.2				
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Comments :

1 BT redd

Form Number
5

Bed Material Type						Total LWD Tall	Functional LWD			Cover				Offchannel Habitat			Disturbance Indicators			Riparian Vegetation			Barrie rs
Dom.	Sub- Dom.	D90 (mm)	Compa ction	SG Type	SG Amt		10 - 20 mm	20 - 50 mm	>50c	Cover Type 1	%	Cover Type 2	%	Type	Access	Length (m)	1	2	3	Type	Structur e	Canopy Closure	
G	C	80	M	R	H	39	20	16	3	LWD	15	DP	10				DW			M	MF	1	N

G	C	80	M	R	H	29	14	15		C	15	OV	5				DW			M	MF	1	N
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C	G	110	M	R	L	38	24	13	1	LWD	5	C	3	SC	G	300	DW			M	MF	1	N
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G	C	80	M	R	H	63	27	34	3	LWD	50	OV	5	SC	G	370	WG	DW		M	MF	1	N
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C	G	110	M	R	L	53	23	25	5	LWD	10	OV	5				DW			M	MF	1	N
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Level 1 - Habitat Summary Diagnosis Rep

6	WIGWAM RIVER	6	6	11			410	P	1	40	0.64	2	1.09	76.8	14.1	1.5	0.5	1	S
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Comments :

4 BT redds. Photos: Roll W64 F20

7	WIGWAM RIVER	6	6	11	653835	5441798	450	R	1	50	0.64	0.8	0.44	85	23				
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Comments :

2 BT redds. Photos: Roll W64 F19

8	WIGWAM RIVER	6	6	11	653800	5441846	500	P	1	20	0.64	1.45	0.84	84.2	14.4	1	0.3	0.7	S
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Comments :

No BT redds observed. Photos: Roll W64 F18

9	WIGWAM RIVER	6	6	11			520	G	1	40	0.64	1.1	0.67	90.8	17.6				
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Comments :

6 BT redds observed. Photos: Roll W64 F16-17

10	WIGWAM RIVER	6	6	11	653770	5441871	600	P	3	10	0.64	1.7	1.02	69.2	30.6	1.1	0.4	0.7	S
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Comments :

No BT redds. Photos: Roll W64 F15

11	WIGWAM RIVER	6	6	11	653802	5441896	560	R	1	110	0.64	0.9	0.34	69.2	30.6				
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Comments :

Photos: Roll W64 F13-14

G	C	80	M	R	H	35	16	18	1	LWD	30	C	10	SC	P	40	DW	PD	EB	M	MF	1	N
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G	C	80	M	R	H	31	20	9	2	LWD	5	C	5	SC	G	100	DW	PD	MB	M	MF	1	N
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G	S	80	M	R	H	13	9	4		LWD	10	SWD	15				DW	PD	EB	M	MF	1	N
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G	C	80	M	R	H	17	13	4		LWD	1	OV	5	SC	P	500	DW	PD		M	MF	1	N
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G	C	80	M	R	L	4		4		LWD	30	C	10				DW	MB	MC	M	MF	1	N
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G	C	80	M	R	L	31	17	10	4	DP	8	LWD	2	SC	G	370	DW	MB	MC	M	MF	1	N
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Appendix D

Channel Survey Data

Longitudinal Survey**Location:** Wigwam River**Reach:** 5**Site:** 1**UTM:** start 648335E, 5449685N

end 648110E, 5449910N

Crew: SC/AP/KM**Date:** 20/09/2000**Benchmark UTM:**

BM1: 648333E, 5449663N

BM2: 648108E, 5449915N

Benchmark Elevations:

BM1: 1120.000

TP1: 1117.950

TP2: 1116.509

TP2.5: 1118.231

BM2: 1116.894

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
BM1	0	2.221	0.350	1.871	1117.779	1118.129	boulder	riffle	
1120 m	10	2.298	0.300	1.998	1117.702	1118.002	cobble	riffle	
	20	2.509	0.320	2.189	1117.491	1117.811	cobble	riffle	
	30	2.8	0.300	2.500	1117.200	1117.500	cobble	riffle	
	40	3.155	0.620	2.535	1116.845	1117.465	cobble	riffle	
	50	3.111	0.550	2.561	1116.889	1117.439	cobble	riffle	
	60	3.196	0.570	2.626	1116.804	1117.374	boulder	riffle	
	70	3.345	0.510	2.835	1116.655	1117.165	boulder	riffle	
	80	3.547	0.540	3.007	1116.453	1116.993	boulder	riffle	
	90	3.677	0.580	3.097	1116.323	1116.903	boulder	riffle	
TP1	100	3.981	0.910	3.071	1116.019	1116.929	cobble	riffle	
1117.95 m	110	2.547	0.940	1.607	1115.403	1116.343	gravel	glide	
	120	2.457	0.800	1.657	1115.493	1116.293	cobble	glide	
	130	2.438	0.810	1.628	1115.512	1116.322	cobble	glide	
	140	2.382	0.730	1.652	1115.568	1116.298	boulder	glide	
	150	2.262	0.590	1.672	1115.688	1116.278	cobble	glide	two BT redds near LUB
	160	2.149	0.475	1.674	1115.801	1116.276	boulder	glide	one BT redd near LUB
	170	2.179	0.455	1.724	1115.771	1116.226	cobble	glide	
	180	2.207	0.430	1.777	1115.743	1116.173	cobble	riffle	
	190	2.219	0.345	1.874	1115.731	1116.076	boulder	riffle	
	200	2.478	0.480	1.998	1115.472	1115.952	boulder	riffle	
	210	2.582	0.485	2.097	1115.368	1115.853	cobble	riffle	
	220	2.681	0.480	2.201	1115.269	1115.749	cobble	riffle	

Pool Cross Sectional Survey**Location:** Wigwam River**Reach:** 5**Site:** 1**UTM:** 648080E, 5449780N**Crew:** SC/AP/KM**Date:** 21/09/2000**Benchmark UTM:**

BM1: 648333E, 5449663N

BM2: 648108E, 5449915N

pool cross section location at 0+140m of longitudinal survey

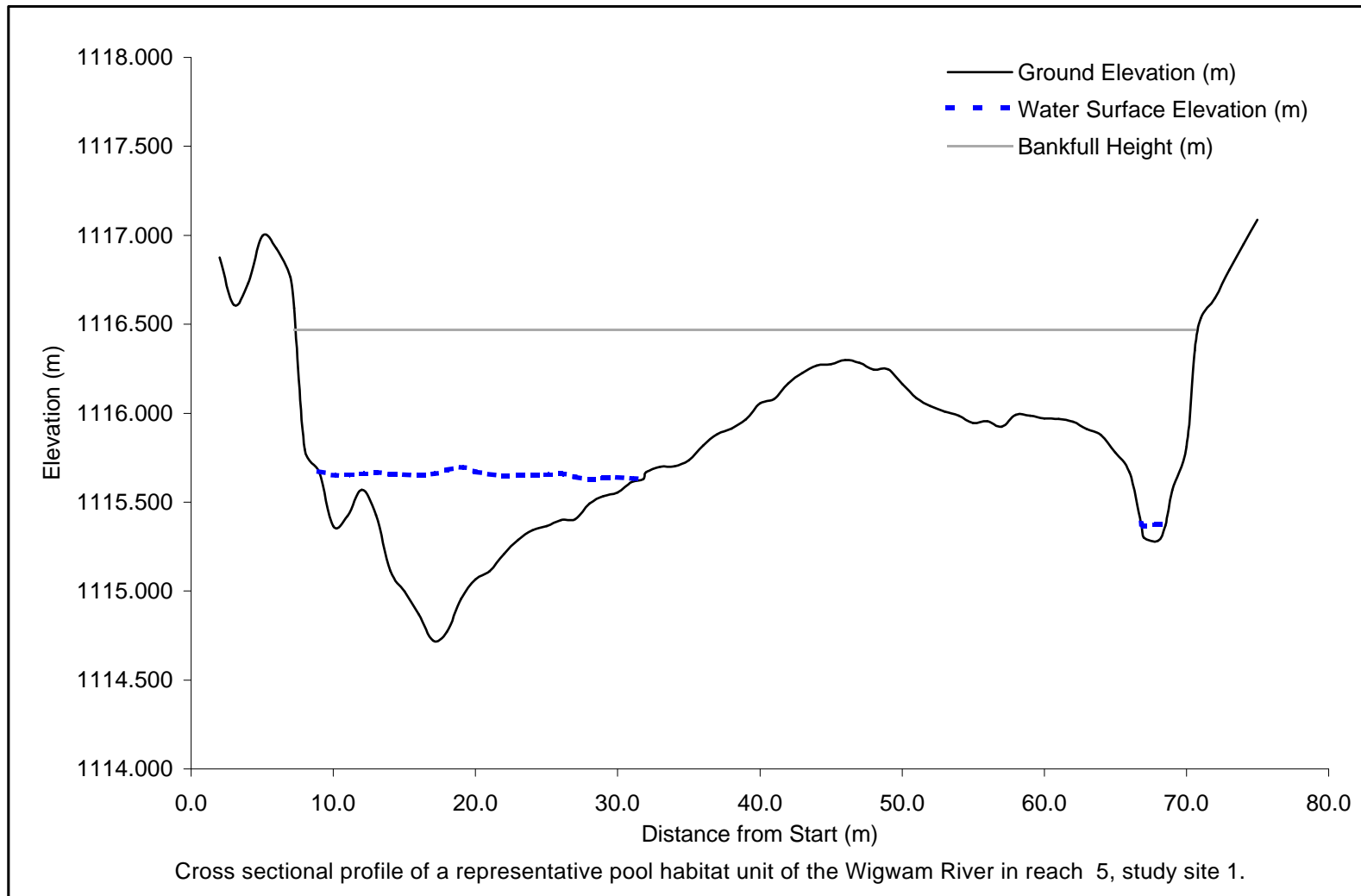
Benchmark Elevations:

TP1: 1117.950 m

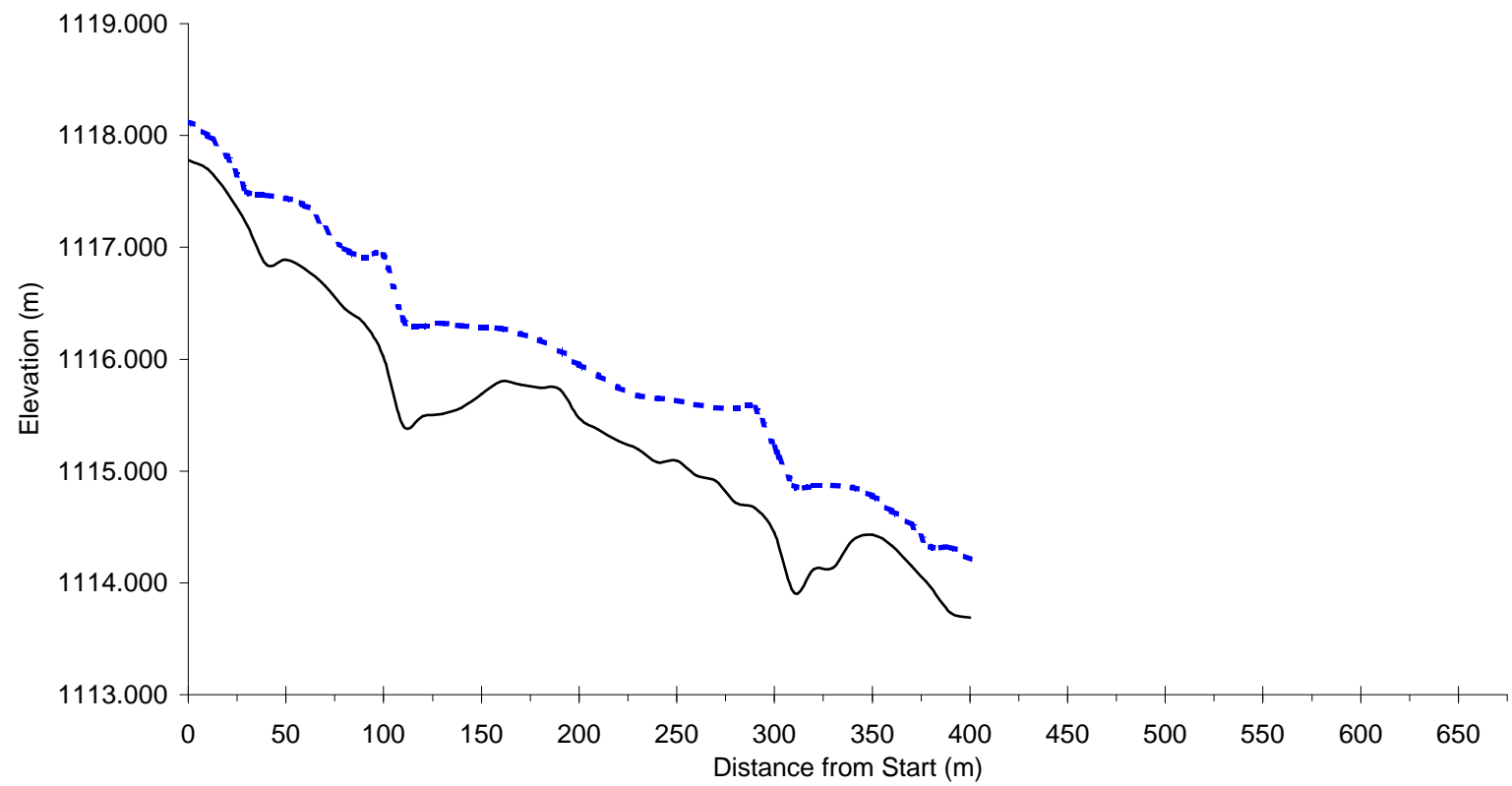
Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
TP1	2.0	1.074			1116.876		vegetation RUB bank, riparian veg.
1117.950 m	3.0	1.341			1116.609		vegetation
	4.0	1.220			1116.730		vegetation
	5.0	0.954			1116.996		vegetation
	6.0	1.023			1116.927		vegetation
	7.0	1.185			1116.765		vegetation
	7.3	1.358			1116.592		vegetation bankfull height
	8.0	2.154			1115.796		cobble
	9.0	2.278	0	2.278	1115.672	1115.672	boulder RUB wetted edge
	10.0	2.584	0.287	2.297	1115.366	1115.653	sand
	11.0	2.527	0.228	2.299	1115.423	1115.651	sand
	12.0	2.381	0.088	2.293	1115.569	1115.657	sand
	13.0	2.523	0.24	2.283	1115.427	1115.667	sand
	14.0	2.835	0.541	2.294	1115.115	1115.656	sand
	15.0	2.951	0.655	2.296	1114.999	1115.654	sand
	16.0	3.082	0.785	2.297	1114.868	1115.653	boulder
	17.0	3.228	0.935	2.293	1114.722	1115.657	boulder
	18.0	3.179	0.91	2.269	1114.771	1115.681	boulder
	19.0	2.994	0.74	2.254	1114.956	1115.696	cobble
	20.0	2.885	0.605	2.28	1115.065	1115.670	cobble
	21.0	2.838	0.545	2.293	1115.112	1115.657	cobble
	22.0	2.743	0.44	2.303	1115.207	1115.647	cobble
	23.0	2.662	0.365	2.297	1115.288	1115.653	cobble
	24.0	2.608	0.31	2.298	1115.342	1115.652	cobble
	25.0	2.584	0.285	2.299	1115.366	1115.651	cobble

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data			Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
	26.0	2.551	0.26	2.291	1115.399	1115.659	cobble	
	27.0	2.547	0.24	2.307	1115.403	1115.643	cobble	
	28.0	2.459	0.135	2.324	1115.491	1115.626	cobble	
	29.0	2.417	0.105	2.312	1115.533	1115.638	cobble	
	30.0	2.396	0.085	2.311	1115.554	1115.639	cobble	
	31.0	2.336	0.02	2.316	1115.614	1115.634	cobble	
	31.8	2.322	0	2.322	1115.628	1115.628	cobble	LUB wetted edge
	32.0	2.281			1115.669		cobble	
	33.0	2.251			1115.699		cobble	
	34.0	2.249			1115.701		cobble	
	35.0	2.215			1115.735		cobble	
	36.0	2.133			1115.817		cobble	
	37.0	2.068			1115.882		cobble	
	38.0	2.036			1115.914		cobble	
	39.0	1.986			1115.964		cobble	
	40.0	1.894			1116.056		cobble	
	41.0	1.872			1116.078		cobble	
	42.0	1.782			1116.168		gravel	
	43.0	1.723			1116.227		gravel	
	44.0	1.683			1116.267		gravel	
	45.0	1.675			1116.275		gravel	
	46.0	1.651			1116.299		gravel	
	47.0	1.668			1116.282		gravel	
	48.0	1.705			1116.245		gravel	
	49.0	1.702			1116.248		gravel	
	50.0	1.785			1116.165		cobble	
	51.0	1.866			1116.084		cobble	
	52.0	1.910			1116.040		cobble	
	53.0	1.941			1116.009		cobble	
	54.0	1.964			1115.986		gravel	
	55.0	2.006			1115.944		cobble	
	56.0	1.996			1115.954		cobble	
	57.0	2.025			1115.925		gravel	

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
	58.0	1.958			1115.992		cobble
	59.0	1.964			1115.986		cobble
	60.0	1.980			1115.970		cobble
	61.0	1.982			1115.968		cobble
	62.0	1.999			1115.951		cobble
	63.0	2.039			1115.911		cobble
	64.0	2.072			1115.878		gravel
	65.0	2.172			1115.778		gravel
	66.0	2.281			1115.669		cobble
	66.8	2.569	0	2.569	1115.381	1115.379	cobble side channel wetted edge
	67.0	2.649	0.065	2.584	1115.301	1115.364	cobble
	68.0	2.667	0.095	2.572	1115.283	1115.376	cobble
	68.5	2.581	0	2.581	1115.369	1115.367	cobble side channel wetted edge
	69.0	2.383			1115.567		gravel
	70.0	2.137			1115.813		cobble
	70.6	1.597			1116.353		vegetation bankfull height, riparian veg
	71.0	1.417			1116.533		vegetation
	72.0	1.302			1116.648		vegetation
	73.0	1.144			1116.806		vegetation
	74.0	1.000			1116.950		vegetation
	75.0	0.862			1117.088		vegetation



Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
TP2 1116.509 m	230	2.756	0.480	2.276	1115.194	1115.674	cobble	riffle	
	240	2.871	0.570	2.301	1115.079	1115.649	cobble	riffle	two BT redds
	250	2.859	0.540	2.319	1115.091	1115.631	cobble	glide	two BT redds near LUB
	260	2.99	0.635	2.355	1114.960	1115.595	cobble	glide	
	270	3.041	0.655	2.386	1114.909	1115.564	sand	glide	
	280	3.235	0.845	2.390	1114.715	1115.560	cobble	glide	
	290	3.282	0.895	2.387	1114.668	1115.563	boulder	glide	
	300	2.78	0.765	2.015	1114.449	1115.214	cobble	glide	
	310	2.6	0.960	1.640	1113.910	1114.870	cobble	glide	
	320	2.387	0.745	1.642	1114.123	1114.868	cobble	glide	
	330	2.376	0.740	1.636	1114.134	1114.874	cobble	glide	four BT redds on LUB
	340	2.132	0.475	1.657	1114.378	1114.853	gravel	glide	
	350	2.078	0.345	1.733	1114.432	1114.777	gravel	glide	
	360	2.179	0.310	1.869	1114.331	1114.641	cobble	riffle	
	370	2.358	0.370	1.988	1114.152	1114.522	cobble	riffle	
	380	2.547	0.360	2.187	1113.963	1114.323	boulder	riffle	
	390	2.78	0.590	2.190	1113.730	1114.320	boulder	riffle	
	400	2.819	0.520	2.299	1113.691	1114.211	boulder	riffle	



Longitudinal profile of a representative two meander lengths of the Wigwam River in reach 5, study site 1.

Pool Cross Sectional Survey**Location:** Wigwam River**Reach:** 5**Site:** 1**UTM:** 648080E, 5449780N**Crew:** SC/AP/KM**Date:** 21/09/2000**Benchmark UTM:**

BM1: 648333E, 5449663N

BM2: 648108E, 5449915N

pool cross section location at 0+140m of longitudinal survey

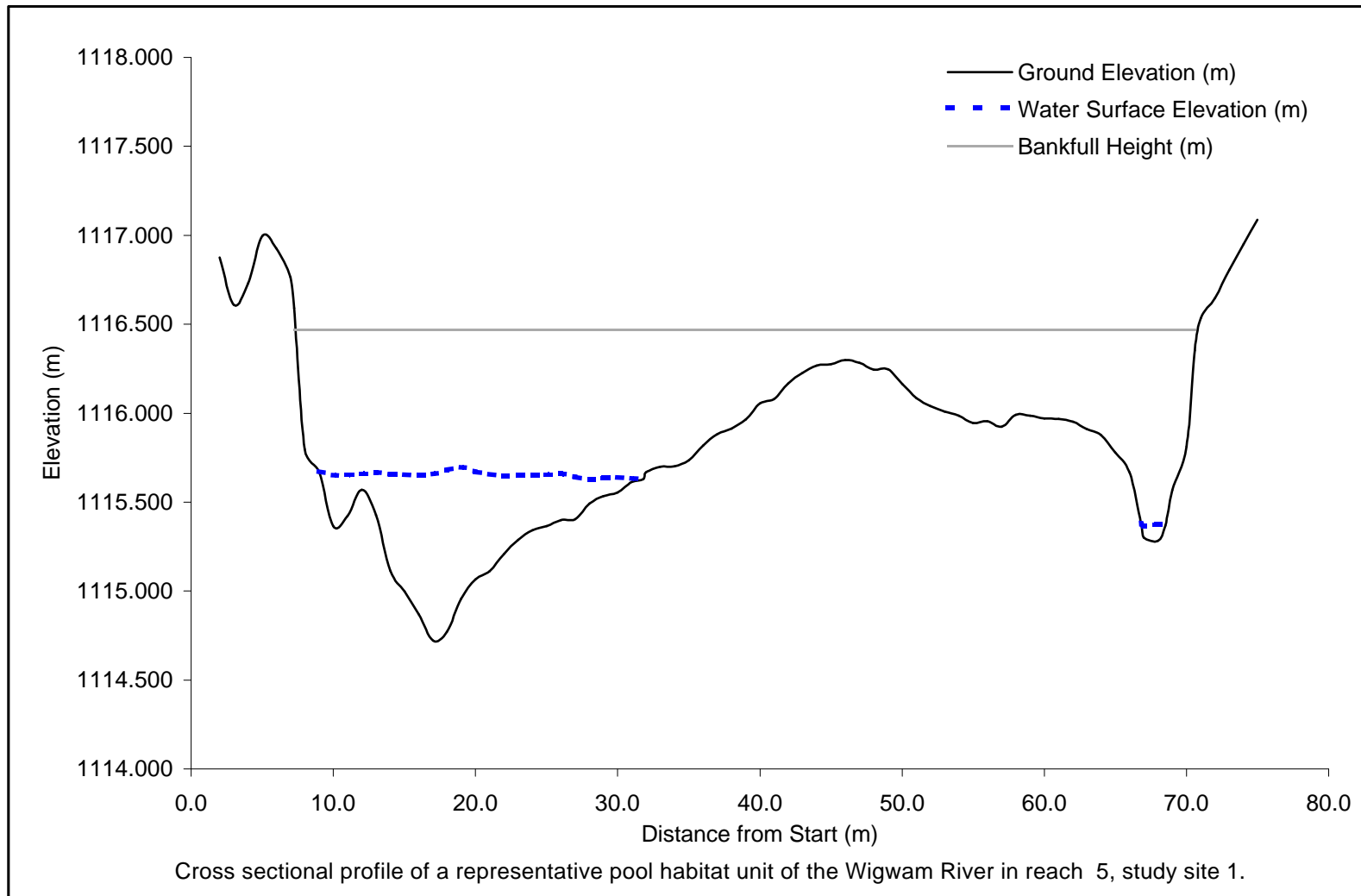
Benchmark Elevations:

TP1: 1117.950 m

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
TP1	2.0	1.074			1116.876		vegetation RUB bank, riparian veg.
1117.950 m	3.0	1.341			1116.609		vegetation
	4.0	1.220			1116.730		vegetation
	5.0	0.954			1116.996		vegetation
	6.0	1.023			1116.927		vegetation
	7.0	1.185			1116.765		vegetation
	7.3	1.358			1116.592		vegetation bankfull height
	8.0	2.154			1115.796		cobble
	9.0	2.278	0	2.278	1115.672	1115.672	boulder RUB wetted edge
	10.0	2.584	0.287	2.297	1115.366	1115.653	sand
	11.0	2.527	0.228	2.299	1115.423	1115.651	sand
	12.0	2.381	0.088	2.293	1115.569	1115.657	sand
	13.0	2.523	0.24	2.283	1115.427	1115.667	sand
	14.0	2.835	0.541	2.294	1115.115	1115.656	sand
	15.0	2.951	0.655	2.296	1114.999	1115.654	sand
	16.0	3.082	0.785	2.297	1114.868	1115.653	boulder
	17.0	3.228	0.935	2.293	1114.722	1115.657	boulder
	18.0	3.179	0.91	2.269	1114.771	1115.681	boulder
	19.0	2.994	0.74	2.254	1114.956	1115.696	cobble
	20.0	2.885	0.605	2.28	1115.065	1115.670	cobble
	21.0	2.838	0.545	2.293	1115.112	1115.657	cobble
	22.0	2.743	0.44	2.303	1115.207	1115.647	cobble
	23.0	2.662	0.365	2.297	1115.288	1115.653	cobble
	24.0	2.608	0.31	2.298	1115.342	1115.652	cobble
	25.0	2.584	0.285	2.299	1115.366	1115.651	cobble

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data			Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
	26.0	2.551	0.26	2.291	1115.399	1115.659	cobble	
	27.0	2.547	0.24	2.307	1115.403	1115.643	cobble	
	28.0	2.459	0.135	2.324	1115.491	1115.626	cobble	
	29.0	2.417	0.105	2.312	1115.533	1115.638	cobble	
	30.0	2.396	0.085	2.311	1115.554	1115.639	cobble	
	31.0	2.336	0.02	2.316	1115.614	1115.634	cobble	
	31.8	2.322	0	2.322	1115.628	1115.628	cobble	LUB wetted edge
	32.0	2.281			1115.669		cobble	
	33.0	2.251			1115.699		cobble	
	34.0	2.249			1115.701		cobble	
	35.0	2.215			1115.735		cobble	
	36.0	2.133			1115.817		cobble	
	37.0	2.068			1115.882		cobble	
	38.0	2.036			1115.914		cobble	
	39.0	1.986			1115.964		cobble	
	40.0	1.894			1116.056		cobble	
	41.0	1.872			1116.078		cobble	
	42.0	1.782			1116.168		gravel	
	43.0	1.723			1116.227		gravel	
	44.0	1.683			1116.267		gravel	
	45.0	1.675			1116.275		gravel	
	46.0	1.651			1116.299		gravel	
	47.0	1.668			1116.282		gravel	
	48.0	1.705			1116.245		gravel	
	49.0	1.702			1116.248		gravel	
	50.0	1.785			1116.165		cobble	
	51.0	1.866			1116.084		cobble	
	52.0	1.910			1116.040		cobble	
	53.0	1.941			1116.009		cobble	
	54.0	1.964			1115.986		gravel	
	55.0	2.006			1115.944		cobble	
	56.0	1.996			1115.954		cobble	
	57.0	2.025			1115.925		gravel	

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
	58.0	1.958			1115.992		cobble
	59.0	1.964			1115.986		cobble
	60.0	1.980			1115.970		cobble
	61.0	1.982			1115.968		cobble
	62.0	1.999			1115.951		cobble
	63.0	2.039			1115.911		cobble
	64.0	2.072			1115.878		gravel
	65.0	2.172			1115.778		gravel
	66.0	2.281			1115.669		cobble
	66.8	2.569	0	2.569	1115.381	1115.379	cobble side channel wetted edge
	67.0	2.649	0.065	2.584	1115.301	1115.364	cobble
	68.0	2.667	0.095	2.572	1115.283	1115.376	cobble
	68.5	2.581	0	2.581	1115.369	1115.367	cobble side channel wetted edge
	69.0	2.383			1115.567		gravel
	70.0	2.137			1115.813		cobble
	70.6	1.597			1116.353		vegetation bankfull height, riparian veg
	71.0	1.417			1116.533		vegetation
	72.0	1.302			1116.648		vegetation
	73.0	1.144			1116.806		vegetation
	74.0	1.000			1116.950		vegetation
	75.0	0.862			1117.088		vegetation



Riffle Cross Sectional Survey**Location:** Wigwam River**Reach:** 5**Site:** 1

riffle cross section location at 0+190 m of longitudinal

UTM: 648156E, 5449814 N**Crew:** SC/AP/KM**Date:** 21/09/2000**Benchmark UTM:**

BM1: 648333E, 5449663N

BM2: 648108E, 5449915N

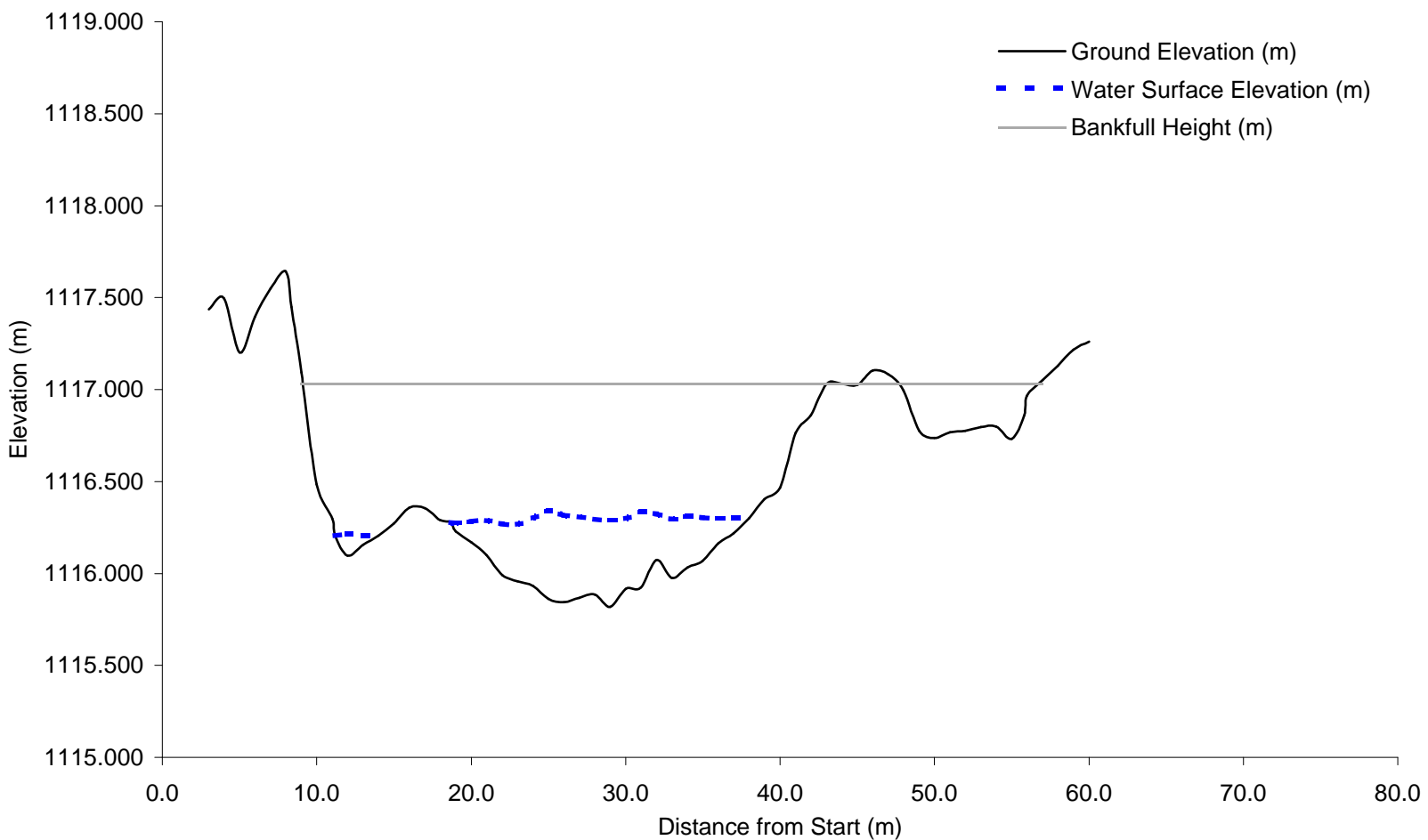
Benchmark elevations:

TP1: 1117.948 m

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
TP1	3.0	0.514			1117.436		
1117.948 m	4.0	0.455			1117.495		
	5.0	0.748			1117.202		
	6.0	0.554			1117.396		
	7.0	0.400			1117.550		
	8.0	0.308			1117.642		
	8.4	0.500			1117.450		cobble
	9.0	0.856			1117.094		cobble bankfull height
	10.0	1.466			1116.484		cobble
	11.0	1.653			1116.297		cobble
	11.2	1.744	0	1.744	1116.206	1116.206	cobble wetted edge
	12.0	1.853	0.115	1.738	1116.097	1116.212	cobble
	13.0	1.794	0.048	1.746	1116.156	1116.204	cobble
	14.0	1.744	0	1.744	1116.206	1116.206	cobble wetted edge
	15.0	1.678			1116.272		
	16.0	1.592			1116.358		
	17.0	1.595			1116.355		
	18.0	1.660			1116.290		
	18.7	1.673	0	1.673	1116.277	1116.277	gravel wetted edge
	19.0	1.722	0.045	1.677	1116.228	1116.273	cobble
	20.0	1.782	0.115	1.667	1116.168	1116.283	cobble
	21.0	1.851	0.19	1.661	1116.099	1116.289	cobble
	22.0	1.960	0.28	1.68	1115.990	1116.270	boulder
	23.0	1.992	0.31	1.682	1115.958	1116.268	boulder
	24.0	2.019	0.37	1.649	1115.931	1116.301	boulder
	25.0	2.087	0.48	1.607	1115.863	1116.343	boulder
	26.0	2.105	0.47	1.635	1115.845	1116.315	boulder

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
	27.0	2.082	0.44	1.642	1115.868	1116.308	boulder	
	28.0	2.065	0.41	1.655	1115.885	1116.295	boulder	
	29.0	2.133	0.47	1.663	1115.817	1116.287	boulder	
	30.0	2.033	0.38	1.653	1115.917	1116.297	boulder	
	31.0	2.027	0.41	1.617	1115.923	1116.333	boulder	
	32.0	1.876	0.25	1.626	1116.074	1116.324	boulder	
	33.0	1.974	0.32	1.654	1115.976	1116.296	boulder	
	34.0	1.918	0.28	1.638	1116.032	1116.312	boulder	
	35.0	1.881	0.235	1.646	1116.069	1116.304	boulder	
	36.0	1.785	0.135	1.65	1116.165	1116.300	boulder	
	37.0	1.733	0.085	1.648	1116.217	1116.302	boulder	
	38.0	1.650	0	1.65	1116.300	1116.300	boulder	wetted edge
	39.0	1.545			1116.405		cobble	
	40.0	1.484			1116.466		cobble	start log jam
	41.0	1.185			1116.765		cobble	
	42.0	1.090			1116.860		sand	
	43.0	0.920			1117.030		sand	end log jam
	44.0	0.920			1117.030		cobble	
	45.0	0.925			1117.025		cobble	
	46.0	0.848			1117.102		gravel	
	47.0	0.868			1117.082		sand	
	48.0	0.956			1116.994		sand	
	49.0	1.175			1116.775		sand	
	50.0	1.214			1116.736		sand	
	51.0	1.182			1116.768		gravel	
	52.0	1.175			1116.775		cobble	
	53.0	1.154			1116.796		gravel	
	54.0	1.150			1116.800		gravel	
	55.0	1.218			1116.732		gravel	
	55.8	1.092			1116.858			
	56.0	0.984			1116.966			bankful height
	57.0	0.898			1117.052			
	58.0	0.822			1117.128			

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
	59.0	0.732			1117.218			
	60.0	0.690			1117.260			



Cross sectional profile of a representative riffle habitat unit of the Wigwam River in reach 5, study site 1.

Differential Levelling Loop - Reach 5, Site 1

Station	Backsight	Height of Instrument	Foresight	Elevation	Comment	Corrected Data	True Elevation (m)
BM1	0.155	5.155		5.000	arbitrary elevation	5.000	1120.000
TP1	0.695	3.662	2.188	2.967		2.969	1117.969
TP2	1.351	2.867	2.146	1.516		1.518	1116.518
BM2			0.975	1.892		1.894	1116.894
BM2	1.187	3.079		1.892		1.894	1116.894
TP2	1.822	3.320	1.581	1.498		1.500	1116.500
TP2.5	2.026	3.795	1.551	1.769		1.771	1116.771
TP1	2.199	5.128	0.866	2.929		2.931	1117.931
BM1			0.143	4.985	error = -0.015	4.987	1119.987

Benchmark Elevations (m)	
BM1	1120.000
BM2	1116.894
TP1	1117.950
TP2	1116.509

Longitudinal Survey**Location:** Wigwam River**Reach:** 6**Site:** 2**UTM:** start 653886E, 5441349N
end 0+670m D/S from start**Crew:** SC/KM**Date:** 03/10/2000**Benchmark UTM:**

BM1 653768E, 5441437N

BM2 653770E, 5441871N

BM3 653800E, 5441846N

Benchmark Elevations:

BM1 1200.000 TP4 1197.453

TP1 1198.365 TP5 1195.963

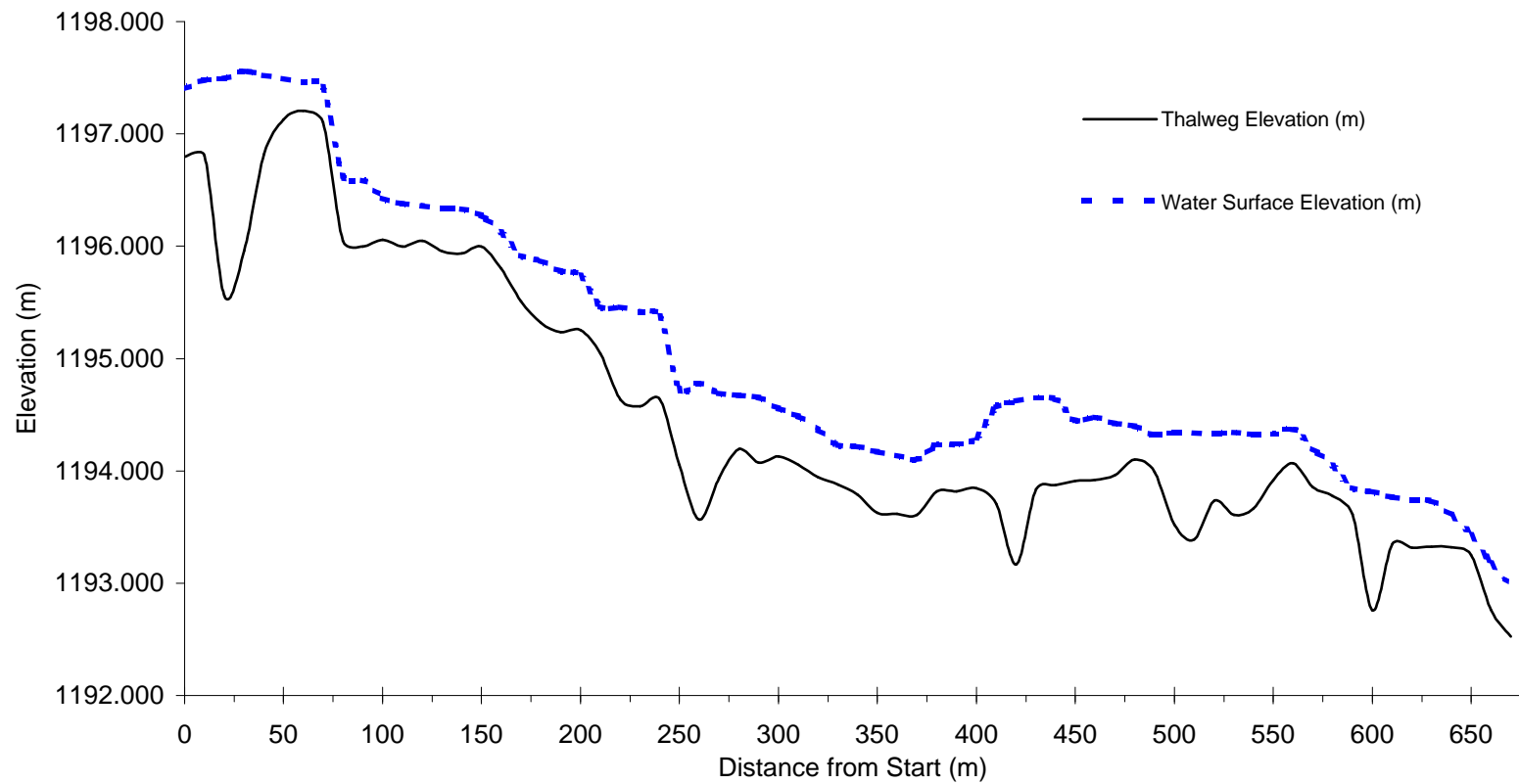
TP2 1197.160 BM2 1195.617

TP3 1196.731 BM3 1197.082

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data			Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
BM1	0	3.203	0.605	2.598	1196.797	1197.402	cobble	pool	
1200.000m	10	3.194	0.675	2.519	1196.806	1197.481	cobble	pool	
	20	4.44	1.935	2.505	1195.560	1197.495	gravel	pool	maximum pool depth
	30	4.04	1.6	2.44	1195.960	1197.56	gravel	pool	
	40	3.181	0.7	2.481	1196.819	1197.519	gravel	pool	
	50	2.876	0.37	2.506	1197.124	1197.494	gravel	pool	
	60	2.793	0.25	2.543	1197.207	1197.457	cobble	riffle	
	70	2.898	0.315	2.583	1197.102	1197.417	cobble	riffle	
	80	3.95	0.57	3.38	1196.050	1196.62	cobble	riffle	
	90	4.002	0.59	3.412	1195.998	1196.588	cobble	riffle	
	100	2.31	0.37	1.94	1196.055	1196.427	gravel	glide	
TP1	110	2.368	0.38	1.988	1195.997	1196.379	gravel	glide	
1198.365 m	120	2.317	0.31	2.007	1196.048	1196.36	gravel	glide	
	130	2.41	0.38	2.03	1195.955	1196.337	gravel	glide	
	140	2.429	0.395	2.034	1195.936	1196.333	gravel	glide	
	150	2.368	0.275	2.093	1195.997	1196.274	gravel	riffle	
	160	2.565	0.32	2.245	1195.800	1196.122	cobble	riffle	
	170	2.857	0.41	2.447	1195.508	1195.92	cobble	riffle	
	180	3.047	0.55	2.497	1195.318	1195.87	cobble	riffle	
	190	3.13	0.54	2.59	1195.235	1195.777	cobble	riffle	
	200	3.11	0.48	2.63	1195.255	1195.737	cobble	riffle	
	210	3.323	0.42	2.903	1195.042	1195.464	cobble	riffle	

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
TP2 1197.160 m	220	3.729	0.82	2.909	1194.636	1195.458	gravel	pool	
	230	3.79	0.84	2.95	1194.575	1195.417	gravel	pool	
	240	3.729	0.74	2.989	1194.636	1195.378	gravel	pool	
	250	3.104	0.67	2.434	1194.056	1194.727	gravel	pool	
	260	3.594	1.21	2.384	1193.566	1194.777	gravel	pool	
	270	3.225	0.755	2.47	1193.935	1194.691	sand	pool	
	280	2.967	0.48	2.487	1194.193	1194.674	cobble	pool	
	290	3.089	0.58	2.509	1194.071	1194.652	cobble	riffle	
	300	3.032	0.425	2.607	1194.128	1194.554	gravel	riffle	
	310	3.106	0.43	2.676	1194.054	1194.485	gravel	riffle	
	320	3.216	0.42	2.796	1193.944	1194.365	cobble	riffle	
	330	3.284	0.355	2.929	1193.876	1194.232	cobble	riffle	
	340	3.372	0.43	2.942	1193.788	1194.219	cobble	riffle	
	350	3.535	0.545	2.99	1193.625	1194.171	gravel	riffle	
	360	3.542	0.52	3.022	1193.618	1194.139	cobble	riffle	
	370	3.553	0.495	3.058	1193.607	1194.103	cobble	riffle	
TP3 1196.731 m	380	2.912	0.41	2.502	1193.819	1194.229	cobble	riffle	
	390	2.916	0.42	2.496	1193.815	1194.235	cobble	riffle	
	400	2.885	0.45	2.435	1193.846	1194.296	cobble	riffle	
	410	3.025	0.86	2.165	1193.706	1194.566	gravel	pool	
	420	3.563	1.454	2.109	1193.168	1194.622	gravel	pool	
	430	2.893	0.81	2.083	1193.838	1194.648	gravel	pool	
	440	2.856	0.765	2.091	1193.875	1194.64	gravel	pool	
	450	2.821	0.54	2.281	1193.910	1194.45	gravel	riffle	
	460	2.813	0.56	2.253	1193.918	1194.478	gravel	riffle	
	470	2.77	0.46	2.31	1193.961	1194.421	gravel	riffle	
	480	2.631	0.3	2.331	1194.100	1194.4	gravel	riffle	
	490	2.744	0.33	2.414	1193.987	1194.317	gravel	riffle	
	500	2.445	0.82	1.625	1193.518	1194.339	gravel	pool	
TP5	510	2.575	0.95	1.625	1193.388	1194.339	gravel	pool	
	520	2.229	0.6	1.629	1193.734	1194.335	gravel	glide	
	530	2.356	0.735	1.621	1193.607	1194.343	gravel	glide	
	540	2.3	0.66	1.64	1193.663	1194.324	gravel	glide	

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data			Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
1195.963 m	550	2.046	0.41	1.636	1193.917	1194.328	gravel	glide	
	560	1.893	0.3	1.593	1194.070	1194.371	cobble	riffle	
	570	2.107	0.34	1.767	1193.856	1194.197	cobble	riffle	
	580	2.189	0.27	1.919	1193.774	1194.045	cobble	riffle	
	590	2.352	0.24	2.112	1193.611	1193.852	cobble	riffle	
	600	3.205	1.06	2.145	1192.758	1193.819	gravel	pool	
	610	2.614	0.415	2.199	1193.349	1193.765	cobble	riffle	
	620	2.65	0.43	2.22	1193.313	1193.744	cobble	riffle	
	630	2.64	0.41	2.23	1193.323	1193.734	cobble	riffle	
	640	2.645	0.29	2.355	1193.318	1193.609	cobble	riffle	
	650	2.713	0.178	2.535	1193.250	1193.429	cobble	riffle	
	660	3.2	0.41	2.79	1192.763	1193.174	cobble	riffle	
	670	3.437	0.47	2.967	1192.526	1192.997	cobble	riffle	



Longitudinal profile of a representative two meander lengths of the Wigwam River in reach 6, study site 2.

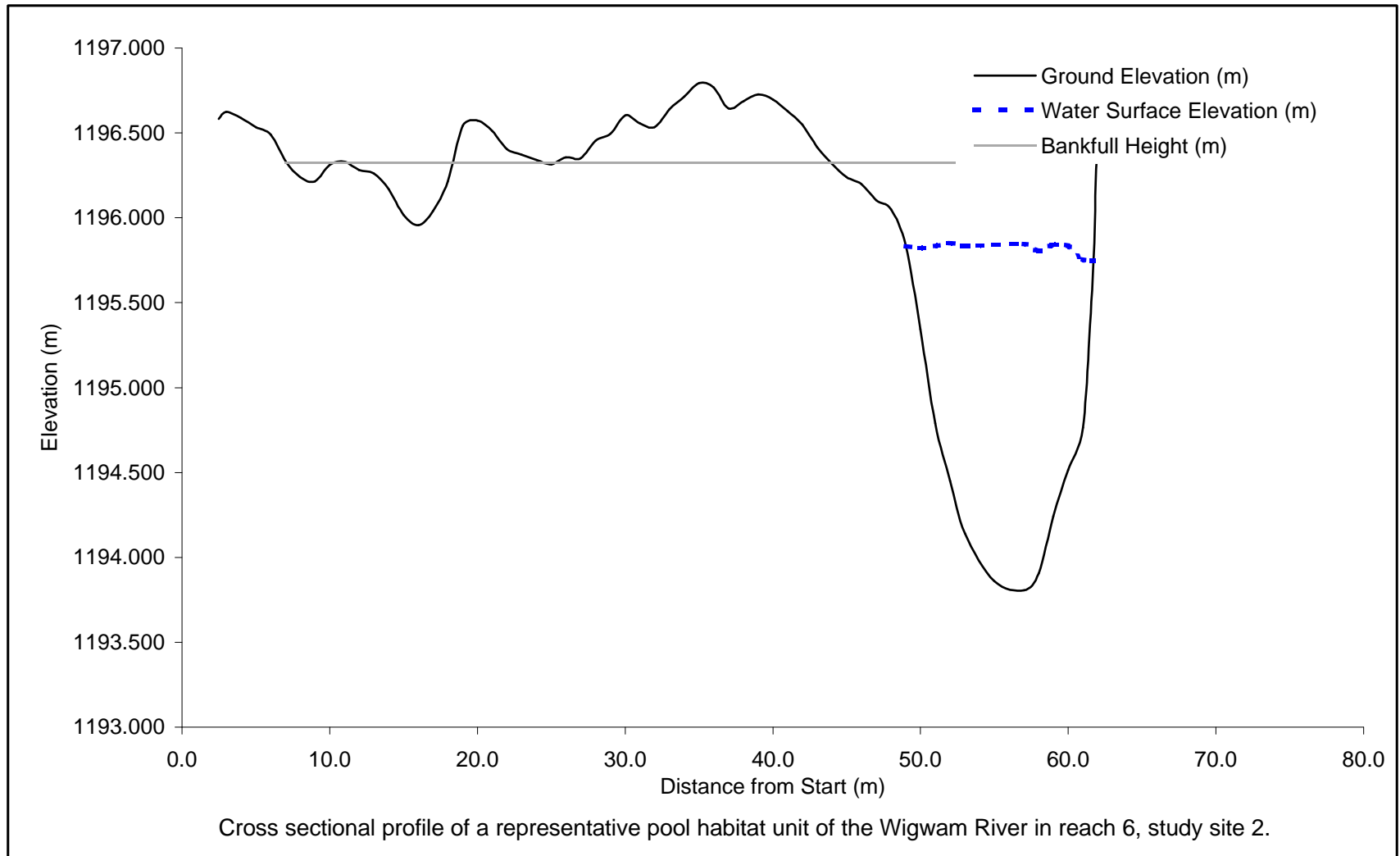
Pool Cross Sectional Survey**Location:** Wigwam River**Reach:** 6**Site:** 2**UTM:** 653836E, 5441375N**Crew:** SC/KM**Date:** 04/10/2000**Benchmark Elevations:**

TP1: 1198.365 m

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data			Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)			
TP1	2.5	1.782			1196.583				RUB bank
1198.365	3.0	1.741			1196.624				
	4.0	1.778			1196.587				
	5.0	1.832			1196.533				
	6.0	1.874			1196.491				
	7.0	2.032			1196.333				
	8.0	2.126			1196.239				bankfull height
	9.0	2.150			1196.215		sand		unvegetated bar
	10.0	2.052			1196.313		sand		
	11.0	2.035			1196.330		sand		
	12.0	2.084			1196.281		sand		
	13.0	2.105			1196.260		sand		
	14.0	2.197			1196.168		sand		
	15.0	2.349			1196.016		gravel		
	16.0	2.409			1195.956		gravel		
	17.0	2.327			1196.038		gravel		
	18.0	2.150			1196.215		gravel		bankfull height
	19.0	1.824			1196.541		gravel		
	20.0	1.792			1196.573		gravel		
	21.0	1.855			1196.510		gravel		
	22.0	1.961			1196.404		gravel		
	23.0	1.994			1196.371		gravel		
	24.0	2.024			1196.341		gravel		
	25.0	2.049			1196.316		gravel		
	26.0	2.009			1196.356		gravel		
	27.0	2.015			1196.350		gravel		
	28.0	1.910			1196.455		gravel		
	29.0	1.869			1196.496		gravel		

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
	30.0	1.762			1196.603		gravel
	31.0	1.809			1196.556		sand
	32.0	1.830			1196.535		sand
	33.0	1.725			1196.640		sand
	34.0	1.650			1196.715		gravel
	35.0	1.570			1196.795		gravel
	36.0	1.597			1196.768		gravel
	37.0	1.721			1196.644		sand
	38.0	1.680			1196.685		sand
	39.0	1.639			1196.726		sand
	40.0	1.670			1196.695		sand
	41.0	1.735			1196.630		gravel
	42.0	1.815			1196.550		sand
	43.0	1.950			1196.415		sand
	44.0	2.047			1196.318		gravel
	45.0	2.125			1196.240		gravel
	46.0	2.167			1196.198		gravel
	47.0	2.262			1196.103		gravel
	48.0	2.316			1196.049		gravel
	49.0	2.532	0.000	2.532	1195.833	1195.833	gravel RUB wetted edge
	50.0	3.020	0.475	2.545	1195.345	1195.820	gravel
	51.0	3.575	1.043	2.532	1194.790	1195.833	gravel
	52.0	3.915	1.400	2.515	1194.450	1195.850	gravel
	53.0	4.225	1.692	2.533	1194.140	1195.832	gravel
	55.0	4.505	1.980	2.525	1193.860	1195.840	finer
	57.0	4.560	2.040	2.520	1193.805	1195.845	finer six BT in pool, redds in pool
	58.0	4.459	1.900	2.559	1193.906	1195.806	finer
	59.0	4.124	1.600	2.524	1194.241	1195.841	finer
	60.0	3.850	1.320	2.530	1194.515	1195.835	finer
	61.0	3.600	0.990	2.610	1194.765	1195.755	finer
	61.7	2.618	0.000	2.618	1195.747	1195.747	finer LUB wetted edge (undercut bank)
	62.0	1.947			1196.418		vegetation bankfull height
	63.0	1.716			1196.649		
	64.0	1.632			1196.733		

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
	65.0	1.633			1196.732			
	66.0	1.648			1196.717			



Differential Levelling Loop - Reach 6, Site 2

Station	Backsight	Height of Instrument	Foresight	Elevation	Comment	Corrected Elevation	True Elevation (m)
BM1	0.827	5.827		5.000	arbitrary elevation	5.000	1200.000
TP1	1.513	4.862	2.478	3.349		3.348	1198.348
TP2	2.065	4.213	2.714	2.148		2.147	1197.147
TP3	1.883	3.605	2.491	1.722		1.721	1196.721
TP4	0.569	3.021	1.153	2.452		2.451	1197.451
TP5	1.058	2.020	2.059	0.962		0.961	1195.961
BM2			1.402	0.618		0.617	1195.617
BM2	1.403	2.021		0.618		0.617	1195.617
TP5	1.999	2.964	1.056	0.965		0.964	1195.964
BM3			0.881	2.083	elevation only	2.082	1197.082
TP4	1.347	3.803	0.508	2.456		2.455	1197.455
TP3	2.324	4.066	2.061	1.742		1.741	1196.741
TP2	2.668	4.842	1.892	2.174		2.173	1197.173
TP1	2.487	5.871	1.458	3.384		3.383	1198.383
BM1		5.013	0.858	5.013	error = +0.013	5.012	1200.012

Benchmark Elevations (m)	
BM1	1200.000
TP1	1198.365
TP2	1197.160
TP3	1196.731
TP4	1197.453
TP5	1195.963
BM2	1195.617
BM3	1197.082

Longitudinal Survey**Location:** Wigwam River**Reach:** 7**Site:** 3**UTM:** start 655471E, 5438625N

end 654977E, 5439074N

Crew: SC/KM**Date:** 28/09/2000**Benchmark UTM:**

BM1: 655348E, 5438656N

BM2: 655016E, 5439078N

Benchmark Elevations:

BM1: 1240.000 TP4: 1235.876

TP1: 1237.611 TP5: 1235.541

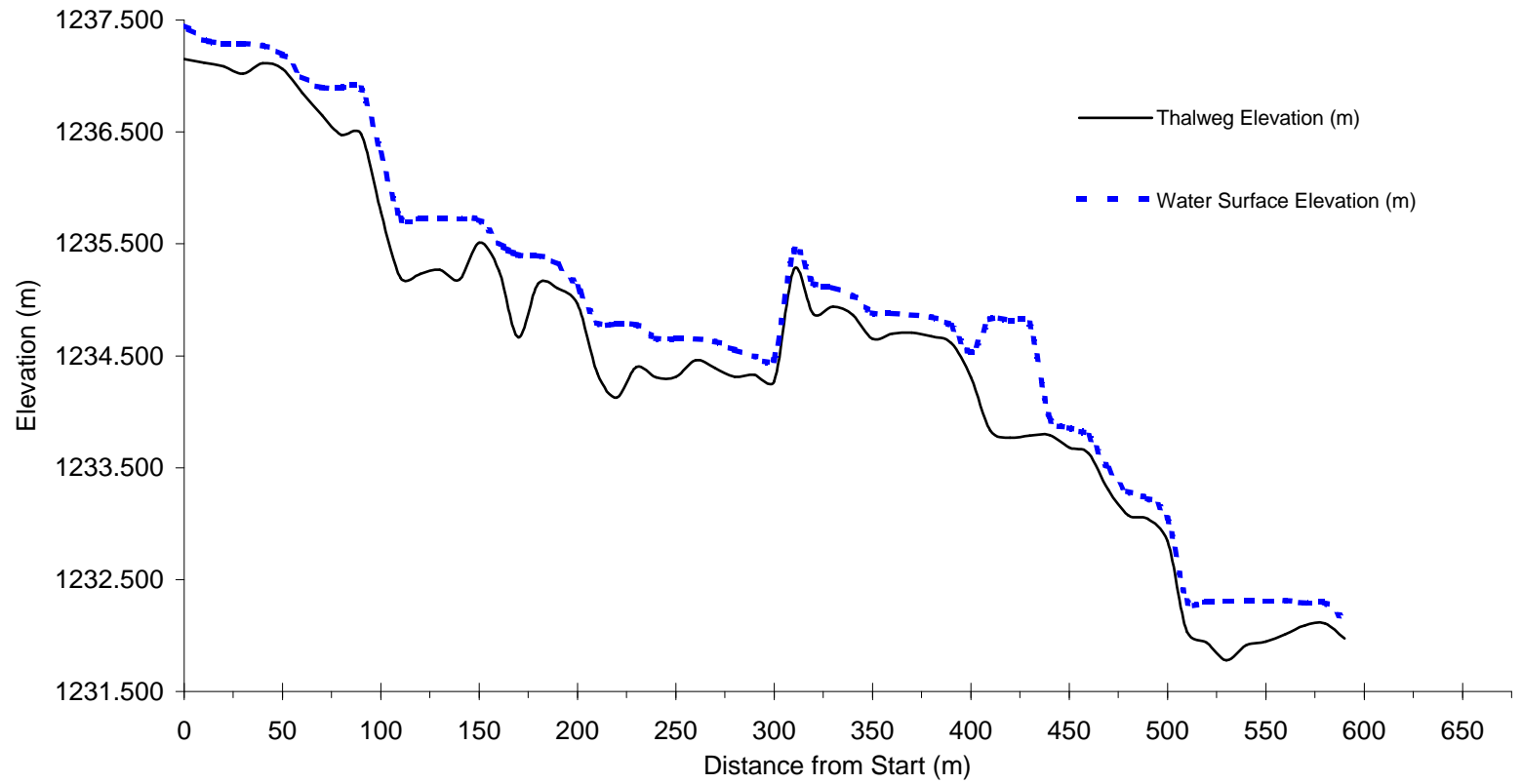
TP2: 1237.393 BM2: 1236.712

TP3: 1236.671

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
BM1	0	2.848	0.300	2.548	1237.152	1237.452	cobble	riffle	
1240 m	10	2.880	0.203	2.677	1237.120	1237.323	cobble	riffle	
	20	2.912	0.205	2.707	1237.088	1237.293	cobble	riffle	
	30	2.980	0.270	2.710	1237.020	1237.290	cobble	riffle	
	40	2.888	0.161	2.727	1237.112	1237.273	gravel	riffle	
	50	2.935	0.123	2.812	1237.065	1237.188	gravel	riffle	
	60	3.151	0.146	3.005	1236.849	1236.995	gravel	riffle	
	70	3.352	0.250	3.102	1236.648	1236.898	cobble	glide	
	80	3.526	0.423	3.103	1236.474	1236.897	cobble	glide	
	90	3.516	0.408	3.108	1236.484	1236.892	cobble	glide	
	100	3.020	0.524	2.497	1235.785	1236.308	cobble	glide	
TP1 1237.611 m	110	2.418	0.536	1.882	1235.193	1235.726	cobble	glide	
	120	2.379	0.495	1.884	1235.232	1235.724	cobble	glide	
	130	2.342	0.457	1.885	1235.269	1235.723	cobble	glide	
	140	2.432	0.543	1.889	1235.179	1235.719	cobble	glide	
	150	2.099	0.208	1.891	1235.512	1235.717	cobble	glide	
	160	2.352	0.255	2.097	1235.259	1235.511	cobble	glide	
	170	2.948	0.738	2.210	1234.663	1235.398	gravel	riffle	
	180	2.468	0.254	2.214	1235.143	1235.394	gravel	pool	
	190	2.510	0.217	2.293	1235.101	1235.315	cobble	pool	
	200	2.431	0.150	2.281	1234.962	1235.110	cobble	riffle	
TP2 1237.393m	210	3.050	0.452	2.598	1234.343	1234.793	cobble	riffle	
	220	3.266	0.661	2.605	1234.127	1234.786	cobble	pool	
	230	2.993	0.379	2.614	1234.400	1234.777	boulder	pool	

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data			Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
TP3 1236.671 m	240	3.085	0.350	2.735	1234.308	1234.656	cobble	pool	
	250	3.083	0.348	2.735	1234.310	1234.656	boulder	glide	
	260	2.931	0.190	2.741	1234.462	1234.650	cobble	glide	
	270	3.002	0.240	2.762	1234.391	1234.629	cobble	glide	
	280	3.083	0.245	2.838	1234.310	1234.553	gravel	riffle	
	290	3.062	0.170	2.892	1234.331	1234.499	cobble	riffle	
	300	3.120	0.200	2.920	1234.273	1234.471	gravel	riffle	
	310	1.396	0.158	1.238	1235.275	1235.430	cobble	riffle	
	320	1.797	0.278	1.519	1234.874	1235.149	cobble	riffle	
	330	1.731	0.175	1.556	1234.940	1235.112	cobble	riffle	
	340	1.804	0.166	1.638	1234.867	1235.030	cobble	riffle	
	350	2.021	0.235	1.786	1234.650	1234.882	cobble	riffle	
	360	1.974	0.183	1.791	1234.697	1234.877	gravel	glide	
	370	1.964	0.162	1.802	1234.707	1234.866	gravel	glide	
	380	1.995	0.172	1.823	1234.676	1234.845	gravel	glide	
	390	2.057	0.158	1.899	1234.614	1234.769	gravel	glide	
	400	2.365	0.226	2.139	1234.306	1234.529	gravel	riffle	
TP4 1235.876 m	410	2.044	0.199	1.845	1233.832	1234.823	cobble	riffle	
	420	2.110	0.255	1.855	1233.766	1234.813	cobble	riffle	
	430	2.091	0.215	1.876	1233.785	1234.792	gravel	glide	
	440	2.086	0.150	1.936	1233.790	1233.938	cobble	glide	
	450	2.196	0.176	2.020	1233.680	1233.854	cobble	riffle	
	460	2.247	0.153	2.094	1233.629	1233.780	cobble	riffle	
	470	2.571	0.188	2.383	1233.305	1233.491	cobble	riffle	
	480	2.801	0.216	2.585	1233.075	1233.289	boulder	riffle	
	490	2.831	0.180	2.651	1233.045	1233.223	boulder	riffle	
	500	3.035	0.210	2.825	1232.841	1233.049	boulder	riffle	
TP5 1235.541 m	510	3.508	0.275	3.233	1232.033	1232.306	boulder	riffle	
	520	3.605	0.371	3.234	1231.936	1232.305	cobble	glide	
	530	3.762	0.529	3.233	1231.779	1232.306	boulder	glide	
	540	3.629	0.399	3.230	1231.912	1232.309	cobble	glide	
	550	3.595	0.364	3.231	1231.946	1232.308	cobble	glide	
	560	3.530	0.302	3.228	1232.011	1232.311	cobble	glide	
	570	3.449	0.202	3.247	1232.092	1232.292	cobble	glide	
	580	3.432	0.186	3.246	1232.109	1232.293	cobble	glide	

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
	590	3.566	0.158	3.408	1231.975	1232.131	cobble	glide	



Longitudinal profile of a representative two meander lengths of the Wigwam River in reach 7, study site 3.

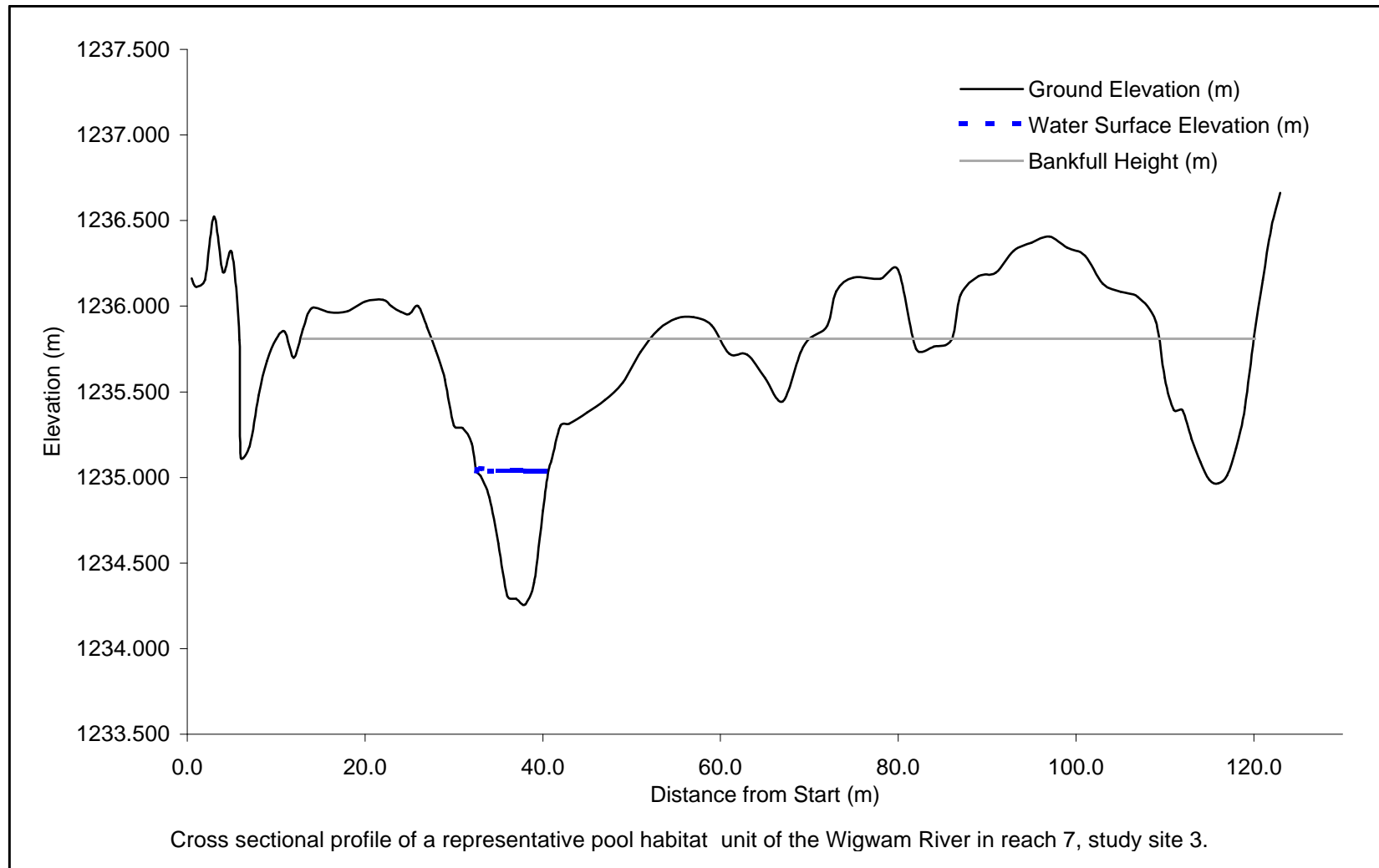
Pool Cross Sectional Survey**Location:** Wigwam River**Reach:** 7**Site:** 3**UTM:** 655250E, 5438840N**Crew:** SC/KM**Date:** 04/10/2000**Benchmark Elevation:**

TP1: 1237.611 m

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
TP1	0.5	1.448			1236.163		vegetation	RUB start
1237.611 m	1.0	1.498			1236.113			
	2.0	1.456			1236.155			
	3.0	1.087			1236.524			log
	4.0	1.411			1236.200			
	5.0	1.299			1236.312			base of large spruce
	5.9	1.807			1235.804			RUB bankfull height
	6.0	2.493			1235.118		sand	
	7.0	2.431			1235.180		sand	beaver dam complex
	8.0	2.134			1235.477		sand	
	9.0	1.929			1235.682		sand	
	10.0	1.805			1235.806		sand	
	11.0	1.762			1235.849		sand	
	12.0	1.912			1235.699		sand	
	13.0	1.749			1235.862		vegetation	bankfull height
	14.0	1.624			1235.987		vegetation	
	16.0	1.646			1235.965		vegetation	
	18.0	1.64			1235.971		vegetation	
	20.0	1.584			1236.027		vegetation	
	22.0	1.573			1236.038		vegetation	
	23.0	1.613			1235.998		vegetation	
	24.0	1.643			1235.968		gravel	
	25.0	1.657			1235.954		gravel	
	26.0	1.611			1236.000		gravel	
	27.0	1.735			1235.876		gravel	LWD backwater, bankfull ht
	28.0	1.872			1235.739		gravel	

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
	29.0	2.04			1235.571		gravel
	30.0	2.308			1235.303		gravel
	31.0	2.324			1235.287		gravel
	32.0	2.411			1235.200		cobble
	32.5	2.572	0	2.572	1235.039	1235.039	gravel RUB wetted edge
	33.0	2.602	0.045	2.557	1235.009	1235.054	finer under LWD jam
	34.0	2.73	0.155	2.575	1234.881	1235.036	finer
	35.0	2.996	0.42	2.576	1234.615	1235.035	finer
	36.0	3.305	0.732	2.573	1234.306	1235.038	sand
	37.0	3.321	0.75	2.571	1234.290	1235.040	gravel
	38.0	3.353	0.78	2.573	1234.258	1235.038	gravel maximum depth of pool
	39.0	3.227	0.655	2.572	1234.384	1235.039	gravel
	40.0	2.805	0.233	2.572	1234.806	1235.039	cobble
	40.7	2.574	0	2.574	1235.037	1235.037	cobble LUB wetted edge
	41.0	2.512			1235.099		cobble
	42.0	2.311			1235.300		cobble
	43.0	2.297			1235.314		cobble
	45.0	2.232			1235.379		cobble
	47.0	2.16			1235.451		cobble
	49.0	2.058			1235.553		gravel
	51.0	1.878			1235.733		gravel
	53.0	1.749			1235.862		gravel
	55.0	1.683			1235.928		gravel
	57.0	1.676			1235.935		gravel
	59.0	1.721			1235.890		gravel
	61.0	1.889			1235.722		gravel
	63.0	1.893			1235.718		gravel
	65.0	2.03			1235.581		gravel
	67.0	2.168			1235.443		gravel
	69.0	1.881			1235.730		clay
	70.0	1.8			1235.811		clay bankfull height
	72.0	1.725			1235.886		vegetation
	73.0	1.525			1236.086		vegetation

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
	75.0	1.443			1236.168		vegetation
	78.0	1.45			1236.161		vegetation small cottonwoods
	80.0	1.4			1236.211		sand
	82.0	1.86			1235.751		sand
	84.0	1.847			1235.764		sand
	86.0	1.806			1235.805		vegetation
	87.0	1.546			1236.065		vegetation grass
	89.0	1.436			1236.175		vegetation
	91.0	1.414			1236.197		gravel
	93.0	1.287			1236.324		gravel sparse cottonwoods
	95.0	1.24			1236.371		gravel
	97.0	1.205			1236.406		sand
	99.0	1.268			1236.343		vegetation
	101.0	1.315			1236.296		vegetation
	103.0	1.48			1236.131		vegetation
	105.0	1.526			1236.085		vegetation
	107.0	1.557			1236.054		vegetation
	109.0	1.7			1235.911		sand
	110.0	2.03			1235.581		sand
	111.0	2.217			1235.394		sand
	112.0	2.22			1235.391		sand
	113.0	2.385			1235.226		clay
	114.0	2.522			1235.089		clay
	115.0	2.625	0.02	2.605	1234.986	1235.003	clay small trickle of water
	116.0	2.645			1234.966		clay
	117.0	2.6			1235.011		vegetation
	118.0	2.44			1235.171		vegetation
	119.0	2.2			1235.411		vegetation
	120.0	1.791			1235.820		vegetation LUB bankfull height
	121.0	1.46			1236.151		vegetation
	122.0	1.155			1236.456		vegetation
	123.0	0.95			1236.661		

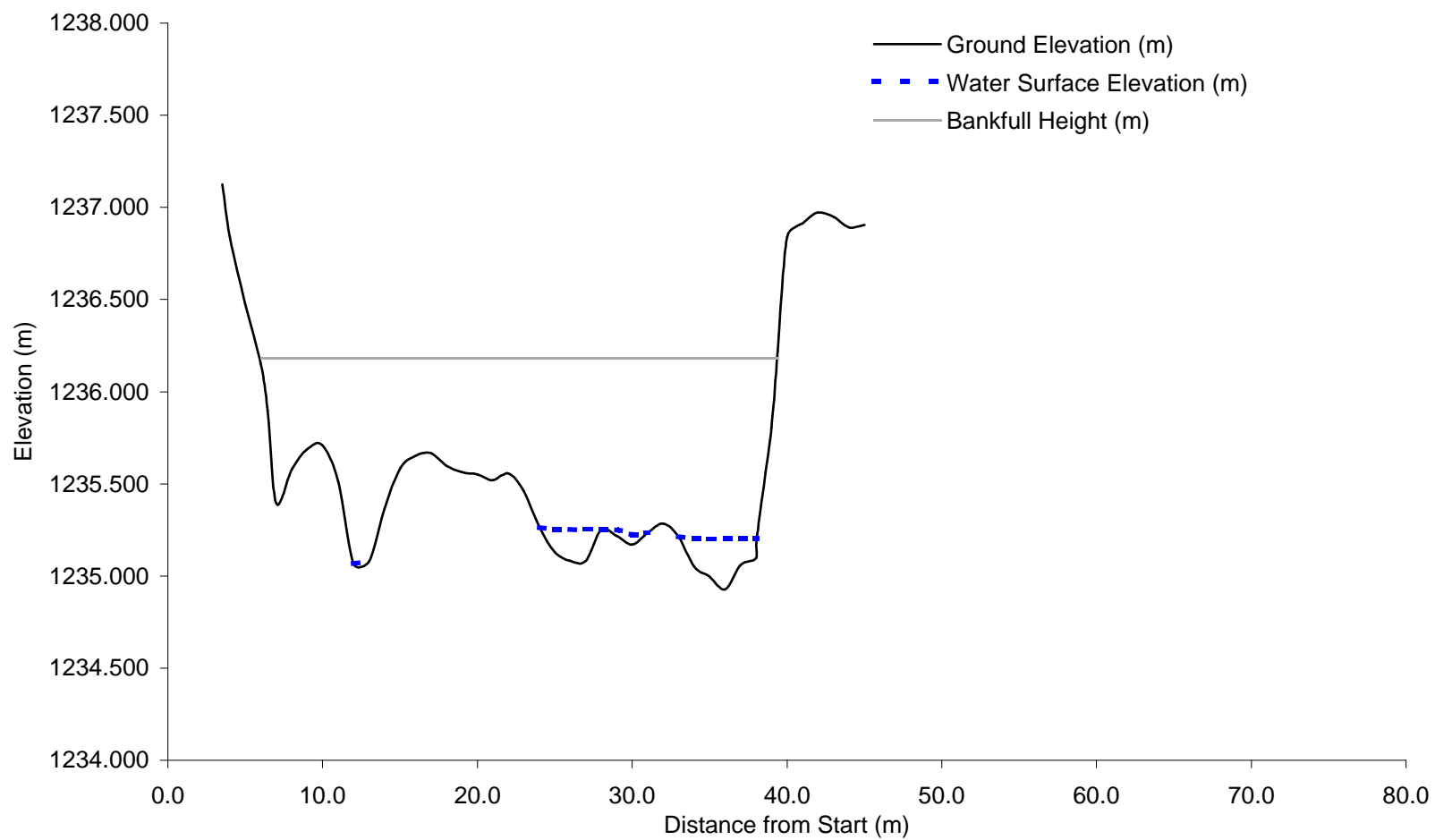


Riffle Cross Sectional Survey**Location:** Wigwam River**Reach:** 7**Site:** 3**UTM:** 655186E, 5438950N**Crew:** SC/KM**Date:** 28/09/2000**Benchmark Elevation:**

TP2: 1237.393 m

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
TP2	3.5	0.267			1237.126		vegetation	
1237.393 m	4.0	0.556			1236.837			
	5.0	0.919			1236.474			
	6.0	1.248			1236.145			RUB bankfull height
	6.5	1.495			1235.898			
	7.0	1.998			1235.395		sand	
	8.0	1.813			1235.580		gravel	
	9.0	1.706			1235.687		gravel	
	10.0	1.683			1235.710		gravel	
	11.0	1.881			1235.512		gravel	beaver dam complex
	12.0	2.327	0	2.327	1235.066	1235.066	sand	side channel outlet
	13.0	2.313	0	2.313	1235.080	1235.080	sand	wetted
	14.0	2.029			1235.364		gravel	
	15.0	1.808			1235.585		gravel	
	16.0	1.741			1235.652		gravel	
	17.0	1.726			1235.667		gravel	
	18.0	1.795			1235.598		gravel	
	19.0	1.830			1235.563		gravel	
	20.0	1.841			1235.552		gravel	
	21.0	1.872			1235.521		gravel	
	22.0	1.838			1235.555		gravel	
	23.0	1.933			1235.460		gravel	
	24.0	2.129	0	2.129	1235.264	1235.264	gravel	RUB wetted edge
	25.0	2.263	0.123	2.140	1235.130	1235.253	gravel	
	26.0	2.310	0.171	2.139	1235.083	1235.254	cobble	
	27.0	2.311	0.169	2.142	1235.082	1235.251	cobble	
	28.0	2.142	0.001	2.141	1235.251	1235.252	boulder	on boulder

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data			Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
	29.0	2.177	0.034	2.143	1235.216	1235.250	cobble	
	30.0	2.224	0.056	2.168	1235.169	1235.225	cobble	
	31.0	2.157	0	2.157	1235.236	1235.236	gravel	wetted edge of bar
	32.0	2.110	0	2.110	1235.283		boulder	unvegetated bar
	33.0	2.180	0	2.180	1235.213	1235.213	boulder	wetted edge of bar
	34.0	2.342	0.15	2.192	1235.051	1235.201	cobble	
	35.0	2.397	0.206	2.191	1234.996	1235.202	cobble	
	36.0	2.466	0.278	2.188	1234.927	1235.205	boulder	thalweg
	37.0	2.333	0.14	2.193	1235.060	1235.200	cobble	
	38.0	2.295	0.104	2.191	1235.098	1235.202	boulder	
	38.1	2.191	0	2.191	1235.202	1235.202	boulder	LUB wetted edge
	39.0	1.587			1235.806		gravel	
	39.4	1.175			1236.218		vegetation	LUB bankfull height
	40.0	0.554			1236.839			
	41.0	0.481			1236.912			
	42.0	0.420			1236.973			
	43.0	0.444			1236.949			
	44.0	0.500			1236.893			
	45.0	0.489			1236.904			



Cross sectional profile of a representative riffle habitat unit of the Wigwam River in reach 7, study site 3.

Differential Levelling Loop - Reach 7, Site 3

Station	Backsight	Height of Instrument	Foresight	Elevation	Comment	Corrected Data	True Elevation (m)
BM1	0.654	5.654		5.000	arbitrary elevation	5	1240.000
TP1	1.807	4.418	3.043	2.611		2.613	1237.613
TP2	1.912	4.303	2.027	2.391		2.393	1237.393
TP3	0.82	2.490	2.633	1.670		1.672	1236.672
TP4	1.283	2.156	1.617	0.873		0.875	1235.875
TP5	1.999	2.538	1.617	0.539		0.541	1235.541
BM2			0.828	1.710		1.712	1236.712
BM2	0.828	2.538		1.710		1.712	1236.712
TP5	1.614	2.153	1.999	0.539		0.541	1235.541
TP4	1.619	2.493	1.279	0.874		0.876	1235.876
TP3	1.882	3.549	0.826	1.667		1.669	1236.669
TP2	2.369	4.760	1.158	2.391		2.393	1237.393
TP1	3.04	5.646	2.154	2.606		2.608	1237.608
BM1			0.669	4.977	error = -0.023	4.979	1239.979

Benchmark Elevations (m)	
BM1	1240.000
TP1	1237.611
TP2	1237.393
TP3	1236.671
TP4	1235.876
TP5	1235.541
BM2	1236.712

Longitudinal Survey**Location:** Wigwam River**Reach:** 9**Site:** 4**UTM:** start 661031E, 5432738N

end 654977E, 5439074N

Crew: SC/KM**Date:** 26/09/2000**Benchmark UTM:**

BM1: 661028E, 5432729N

Benchmark Elevations:

BM1: 1330.000

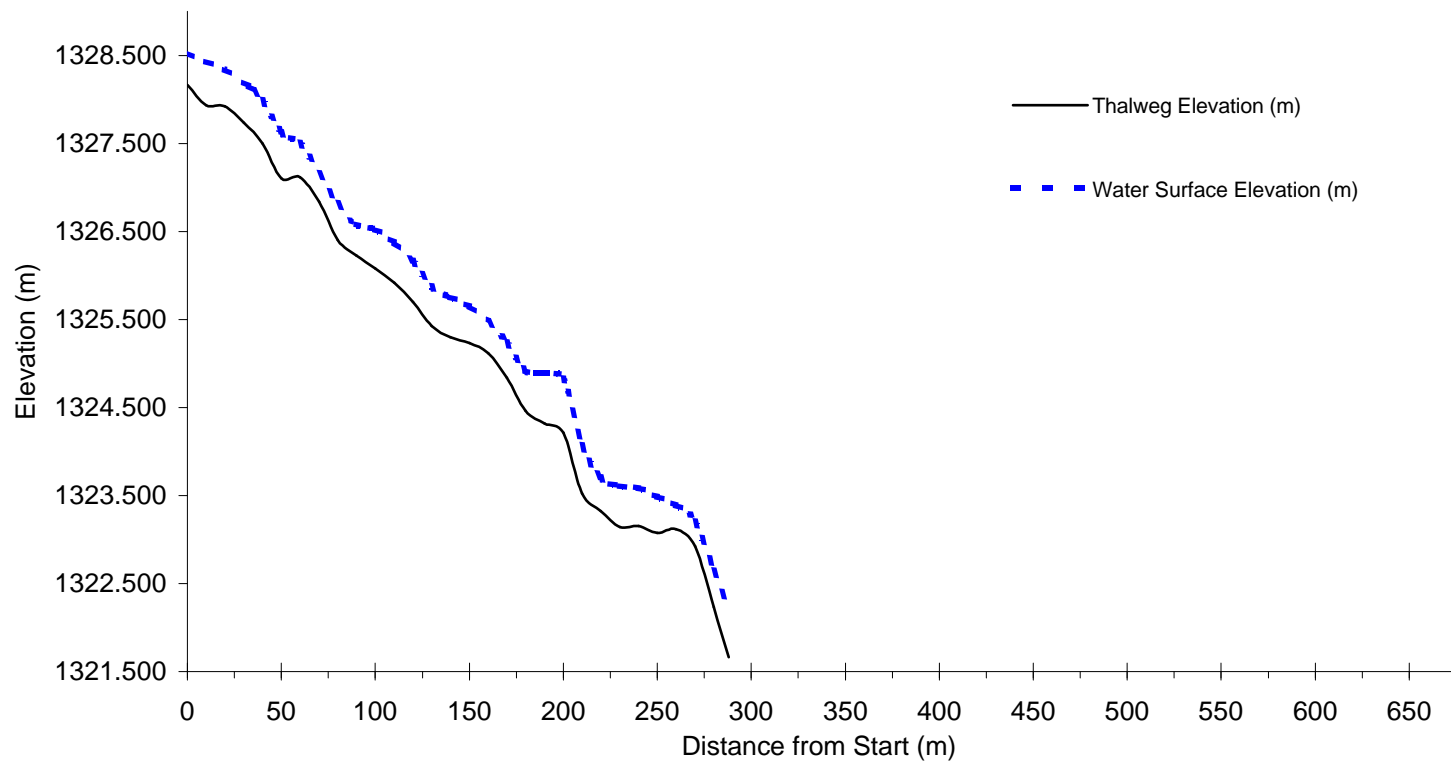
TP1: 1327.783

TP2: 1325.337

BM2: 1327.573

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
BM1	0	1.837	0.365	1.472	1328.163	1328.528	boulder	riffle	
1330 m	10	2.067	0.500	1.567	1327.933	1328.433	boulder	glide	
	20	2.078	0.415	1.663	1327.922	1328.337	boulder	glide	
	30	2.269	0.466	1.803	1327.731	1328.197	boulder	riffle	
	40	2.503	0.492	2.011	1327.497	1327.989	boulder	riffle	
	50	2.895	0.518	2.377	1327.105	1327.623	boulder	riffle	
	60	2.887	0.392	2.495	1327.113	1327.505	boulder	riffle	
	70	3.163	0.321	2.842	1326.837	1327.158	boulder	riffle	
	80	3.596	0.413	3.183	1326.404	1326.817	cobble	pool	
	90	3.775	0.356	3.419	1326.225	1326.581	boulder	riffle	
	100	1.703	0.440	1.263	1326.080	1326.520	boulder	riffle	
TP1 1327.783 m	110	1.864	0.459	1.405	1325.919	1326.378	boulder	riffle	
	120	2.085	0.468	1.617	1325.698	1326.166	boulder	cascade	
	130	2.357	0.450	1.907	1325.426	1325.876	gravel	cascade	
	140	2.483	0.452	2.031	1325.300	1325.752	boulder	glide	
	150	2.551	0.418	2.133	1325.232	1325.650	boulder	glide	
	160	2.667	0.365	2.302	1325.116	1325.481	boulder	riffle	
	170	2.944	0.396	2.548	1324.839	1325.235	boulder	riffle	
	180	3.321	0.455	2.866	1324.462	1324.917	boulder	cascade	
	190	3.464	0.565	2.899	1324.319	1324.884	cobble	glide	
	200	3.566	0.618	2.948	1324.217	1324.835	boulder	glide	
TP2 1325.337 m	210	1.814	0.550	1.264	1323.523	1324.073	cobble	glide	
	220	2.013	0.382	1.631	1323.324	1323.706	boulder	glide	
	230	2.196	0.470	1.726	1323.141	1323.611	cobble	glide	
	240	2.182	0.432	1.750	1323.155	1323.587	cobble	glide	

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
	250	2.260	0.409	1.851	1323.077	1323.486	boulder	riffle	
	260	2.220	0.272	1.948	1323.117	1323.389	cobble	riffle	
	270	2.411	0.280	2.131	1322.926	1323.206	boulder	riffle	
	280	3.105	0.420	2.685	1322.232	1322.652	boulder	cascade	
	288	3.676	0.570	3.106	1321.661	1322.231	boulder	cascade	end of reach



Longitudinal profile of a representative two meander lengths of the Wigwam River in reach 9, study site 4.

Pool Cross Sectional Survey**Location:** Wigwam River**Reach:** 9**Site:** 4**UTM:** 661005E, 5432852N**Crew:** SC/KM**Date:** 27/09/2000**Benchmark UTM:**

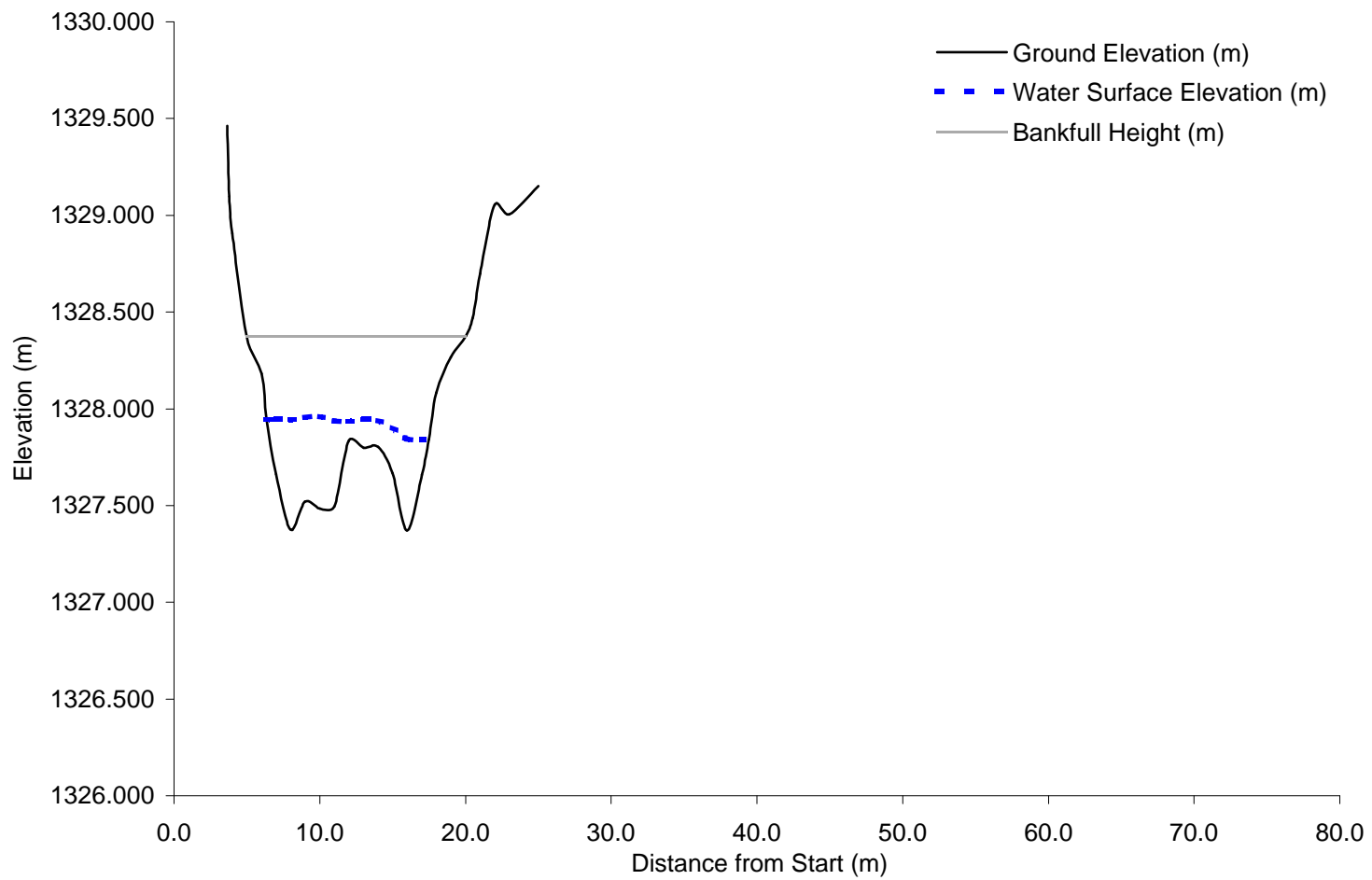
BM1: 661028E, 5432729N

Benchmark Elevation:

BM1: 1340.000 m

TP1: 1337.783 m

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
BM1	3.7	0.538			1329.462		vegetation	RUB start
1330 m	3.8	0.902			1329.098		clay	
	4.0	1.092			1328.908		clay	
	5.0	1.627			1328.373		cobble	RUB bankfull height
	6.0	1.818			1328.182		boulder	
	6.4	2.058	0	2.058	1327.942	1327.942	cobble	RUB wetted edge
	7.0	2.337	0.284	2.053	1327.663	1327.947	boulder	
	8.0	2.623	0.565	2.058	1327.377	1327.942	sand	
	9.0	2.48	0.435	2.045	1327.520	1327.955	boulder	
	10.0	2.516	0.477	2.039	1327.484	1327.961	gravel	
	11.0	2.505	0.441	2.064	1327.495	1327.936	cobble	
	12.0	2.166	0.1	2.066	1327.834	1327.934	gravel	~LWD across channel forming
	13.0	2.202	0.148	2.054	1327.798	1327.946	gravel	sediment wedge on U/S and
	14.0	2.196	0.136	2.06	1327.804	1327.940	gravel	plunge pool on D/S
	15.0	2.332	0.235	2.097	1327.668	1327.903	gravel	
	16.0	2.628	0.472	2.156	1327.372	1327.844	sand	in LWD jam
	17.0	2.341	0.18	2.161	1327.659	1327.839	boulder	
	17.5	2.159	0	2.159	1327.841	1327.841	boulder	LUB wetted edge
	18.0	1.917			1328.083		boulder	
	19.0	1.734			1328.266		gravel	
	20.0	1.626			1328.374		gravel	LUB bankfull height
	20.5	1.53			1328.470		sand	
	21.0	1.302			1328.698		vegetation	
	22.0	0.946			1329.054		vegetation	
	23.0	0.996			1329.004		vegetation	
	25.0	0.85			1329.150		vegetation	



Cross sectional profile of a representative pool habitat unit of the Wigwam River in reach 9, study site 4.

Riffle Cross Sectional Survey**Location:** Wigwam River**Reach:** 9**Site:** 4

cross section located at 0+141m d/s of longitudinal survey

UTM: 660942E, 5432911N**Crew:** SC/KM**Date:** 27/09/2000**Benchmark UTM**

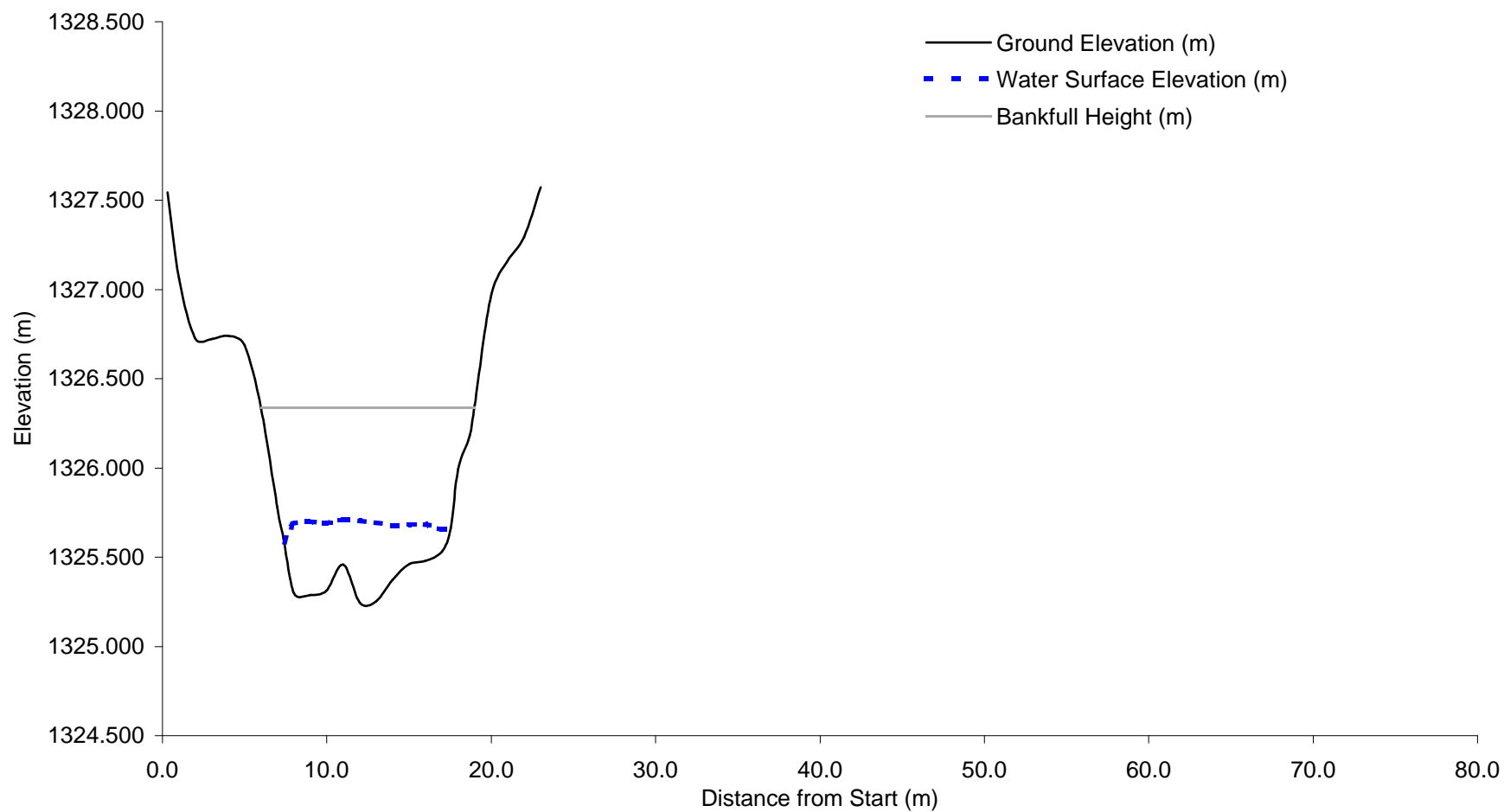
BM1: 661028E, 5432729N

Benchmark Elevation

BM1: 1340.000

TP1: 1337.783

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
TP1	0.3	0.24			1327.543		vegetation
1327.783 m	1.0	0.721			1327.062		vegetation
	2.0	1.057			1326.726		vegetation
	3.0	1.06			1326.723		vegetation
	4.0	1.043			1326.740		vegetation
	5.0	1.095			1326.688		vegetation
	6.0	1.454			1326.329		vegetation bankfull height
	7.0	2.005			1325.778		boulder
	7.4	2.2	0	2.2	1325.583	1325.583	boulder wetted edge
	8.0	2.485	0.39	2.095	1325.298	1325.688	gravel
	9.0	2.495	0.41	2.085	1325.288	1325.698	gravel
	10.0	2.468	0.375	2.093	1325.315	1325.690	cobble
	11.0	2.324	0.25	2.074	1325.459	1325.709	cobble
	12.0	2.539	0.46	2.079	1325.244	1325.704	boulder
	13.0	2.53	0.44	2.09	1325.253	1325.693	boulder
	14.0	2.41	0.305	2.105	1325.373	1325.678	cobble
	15.0	2.322	0.22	2.102	1325.461	1325.681	boulder
	16.0	2.304	0.205	2.099	1325.479	1325.684	cobble
	17.0	2.252	0.125	2.127	1325.531	1325.656	boulder
	17.6	2.121	0	2.121	1325.662	1325.662	boulder wetted edge
	18.0	1.789			1325.994		cobble
	18.7	1.603			1326.180		cobble
	19.0	1.43			1326.353		vegetation bankfull height
	20.0	0.809			1326.974		vegetation
	21.0	0.625			1327.158		vegetation
	22.0	0.49			1327.293		vegetation
	23.0	0.21			1327.573		vegetation



Cross sectional profile of a representative riffle habitat unit of the Wigwam River in reach 9, study site 4.

Differential Levelling Loop - Reach 9, Site 4

Station	Backsight	Height of Instrument	Foresight	Elevation	Comment	True Elevation (m)
BM1	0.318	5.318		5.000	arbitrary elevation	1330.000
TP1	0.063	2.845	2.536	2.782		1327.782
BM2			0.272	2.573	elevation only	1327.573
TP2	1.048	1.385	2.508	0.337		1325.337
BM3			1.311	0.074		1325.074
BM3	1.312	1.386				1325.000
TP2	2.554	2.891	1.049	0.337		1325.337
TP1	2.858	5.641	0.108	2.783		1327.783
BM1			0.639	5.002	error = +0.002 acceptable error	1330.002

Benchmark Elevations (m)	
BM1	1330.000
TP1	1327.782
TP2	1325.337
BM2	1327.573
BM3	1325.037

Longitudinal Survey**Location:** Bighorn Creek**Reach:** 1**Site:** 1**UTM:** 649255E, 5449395N**Crew:** SC/AP/KM**Date:** 19/09/2000**Benchmark UTM:**

BM2: 649256E, 5449358N

RP2: 649106E, 5449472N

RP3: 649150E, 5449385N

RP4: 649203E, 5449419N

Benchmark elevation:

BM2: 1124.459

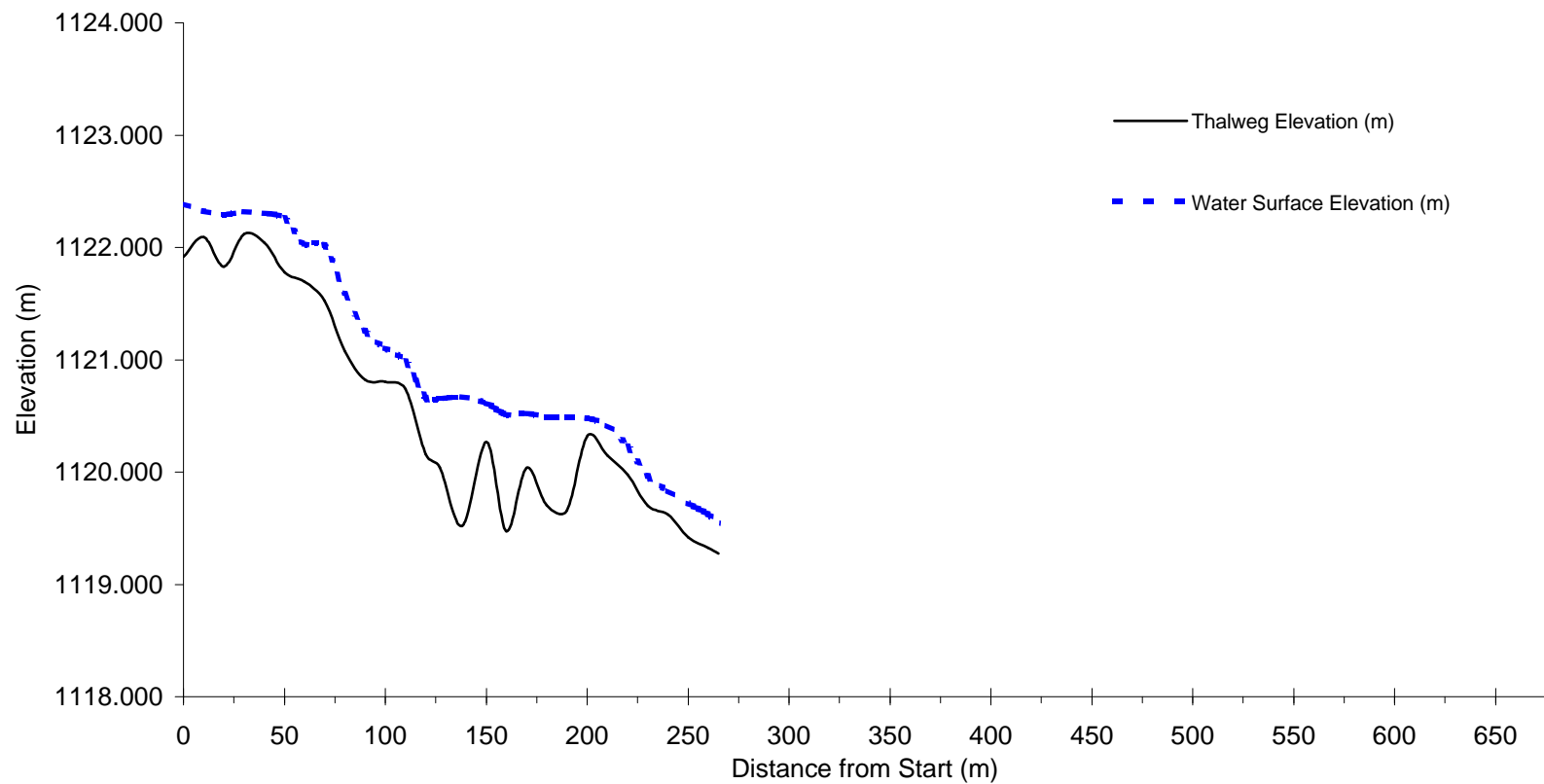
RP2: 1120.448

RP3: 1121.934

RP4: 1123.364

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data			Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
BM2	0	2.543	0.474	2.069	1121.916	1122.390	gravel	glide	3 BT redds, LWD accumulation
1124.459 m	10	2.365	0.229	2.136	1122.094	1122.323	gravel	glide	
	20	2.631	0.465	2.166	1121.828	1122.293	sand	pool	no redds, 0+29m proposed structure
	30	2.338	0.200	2.138	1122.121	1122.321	gravel	glide	
	40	2.417	0.265	2.152	1122.042	1122.307	cobble	glide	
	50	2.680	0.480	2.200	1121.779	1122.259	cobble	glide	
	60	2.766	0.340	2.426	1121.693	1122.033	cobble	riffle	one BT redd, LWD plunge pool
RP4	70	2.934	0.495	2.439	1121.525	1122.020	cobble	riffle	LWD accumulation
1123.364 m	80	2.287	0.510	1.777	1121.077	1121.587	cobble	riffle	one BT redd at 0+73m
	90	2.543	0.434	2.109	1120.821	1121.255	cobble	pool	nice cover
	100	2.561	0.299	2.262	1120.803	1121.102	cobble	riffle	
	110	2.627	0.245	2.382	1120.737	1120.982	cobble	riffle	
	120	3.205	0.500	2.705	1120.159	1120.659	sand	riffle	
	127	3.321	0.610	2.711	1120.043	1120.653	gravel	pool	large log jam
	138	3.843	1.150	2.693	1119.521	1120.671	finer	pool	maximum pool depth
	150	3.095	0.345	2.750	1120.269	1120.614	gravel	pool	one BT redd, one spawning BT pair
	160	3.890	1.040	2.850	1119.474	1120.514	gravel	pool	7 BT, one BT redd, max. depth
	170	3.325	0.482	2.843	1120.039	1120.521	finer	pool	4 BT redds
RP3	180	2.229	0.783	1.446	1119.705	1120.488	gravel	pool	
1121.934 m	190	2.276	0.830	1.446	1119.658	1120.488	cobble	pool	
	200	1.616	0.162	1.454	1120.318	1120.480	cobble	glide	3 BT redds at 0+200 m, pool tail out
	210	1.787	0.270	1.517	1120.147	1120.417	cobble	riffle	
	220	1.958	0.252	1.706	1119.976	1120.228	cobble	riffle	
	230	2.236	0.265	1.971	1119.698	1119.963	cobble	riffle	

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data			Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
	240	2.311	0.210	2.101	1119.623	1119.833	cobble	riffle	
	250	2.514	0.305	2.209	1119.420	1119.725	cobble	glide	one BT redd, LWD accumulation
	260	2.608	0.300	2.308	1119.326	1119.626	cobble	riffle	
	265	2.660	0.268	2.392	1119.274	1119.542	gravel	riffle	



Longitudinal profile of a representative two meander lengths of Bighorn Creek in reach 1, study site 1.

Pool Cross Sectional Survey**Location:** Bighorn Creek**Reach:** 1**Site:** 1

pool cross section located at 0+165 m from start of longitudinal survey

UTM: 649147E, 5449379N**Crew:** SC/AP/KM**Date:** 20/09/2000**Benchmark UTM:**

BM2: 649256E, 5449358N

RP3: 649150E, 5449385N

RP4: 649203E, 5449419N

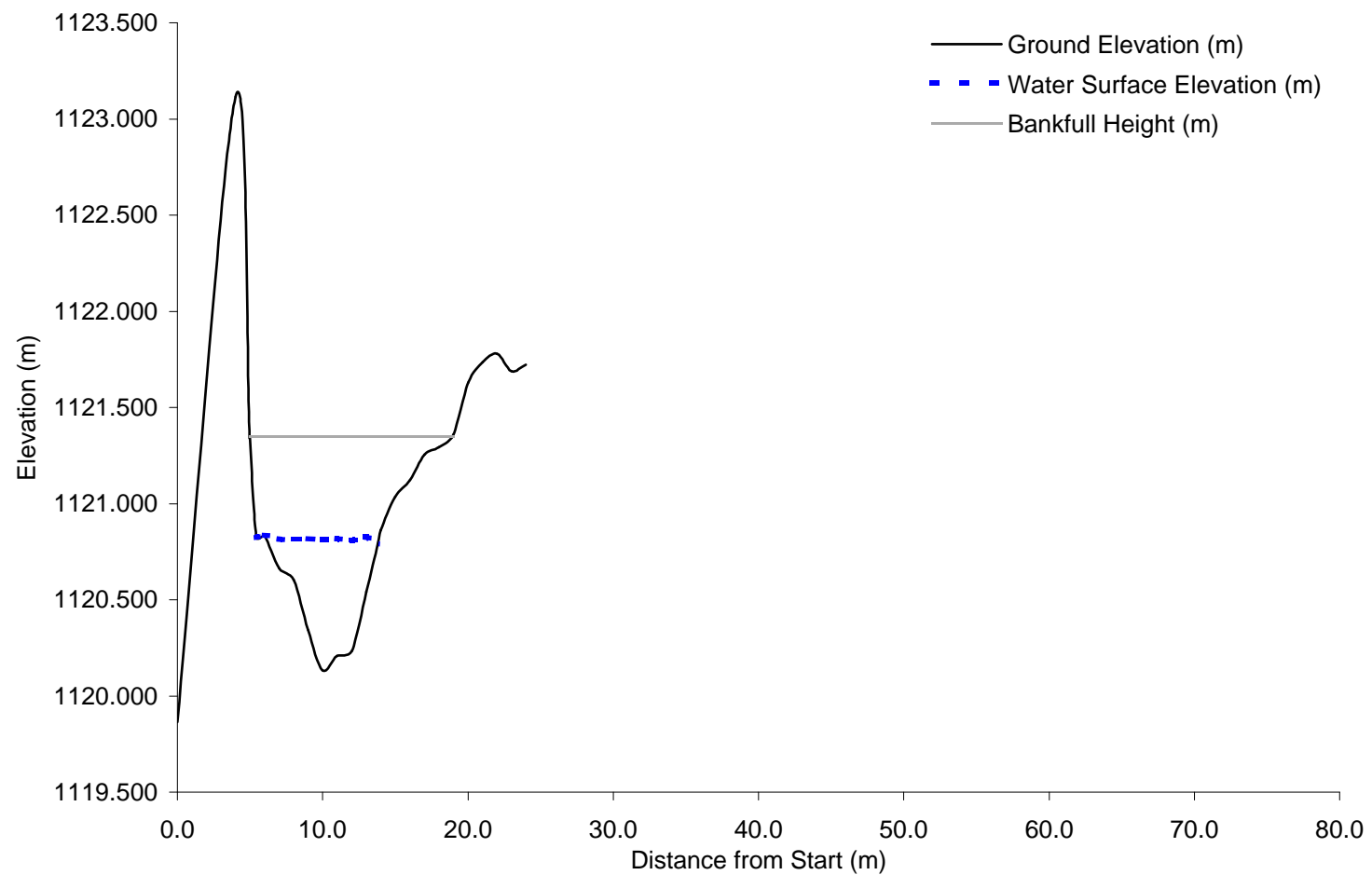
Benchmark elevation:

BM2: 1124.459

RP3: 1121.934

RP4: 1123.364

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Habitat Type	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
RP4	0.0	3.500			1119.864		pool	top of RUB bank
1123.364 m	4.0	0.250			1123.114		clay	pool
	5.0	2.024			1121.340		clay	pool
	5.5	2.540	0.000	2.540	1120.824	1120.824	clay	pool
	6.0	2.531	0.002	2.529	1120.833	1120.835	clay	pool
	7.0	2.700	0.150	2.550	1120.664	1120.814	clay	pool
	8.0	2.761	0.212	2.549	1120.603	1120.815	clay	pool
	9.0	3.021	0.475	2.546	1120.343	1120.818	clay	pool
	10.0	3.231	0.680	2.551	1120.133	1120.813	clay	pool
	11.0	3.155	0.610	2.545	1120.209	1120.819	clay	pool
	12.0	3.129	0.575	2.554	1120.235	1120.810	gravel	pool
	13.0	2.823	0.284	2.539	1120.541	1120.825	gravel	pool
	13.8	2.575	0.000	2.575	1120.789	1120.789	gravel	pool
	14.0	2.502	0.374		1120.862		gravel	pool
	15.0	2.330			1121.034		gravel	pool
	16.0	2.241			1121.123		gravel	pool
	17.0	2.109			1121.255		gravel	pool
	18.0	2.070			1121.294		cobble	pool
	19.0	2.006			1121.358		gravel	pool
	20.0	1.736			1121.628		gravel	pool
	21.0	1.630			1121.734		gravel	pool
	22.0	1.585			1121.779		gravel	pool
	23.0	1.675			1121.689		gravel	pool
	24.0	1.641			1121.723		gravel	pool



Cross sectional profile of a representative pool habitat unit of Bighorn Creek in reach 1, study site 1.

Riffle Cross Sectional Survey**Location:** Bighorn Creek**Reach:** 1**Site:** 1

riffle cross section located at 0+230 m of longitudinal survey

UTM: 649102E, 5449417N**Crew:** SC/AP/KM**Date:** 20/09/2000**Benchmark UTM:**

BM2: 649106E, 5449472N

RP3: 649150E, 5449385N

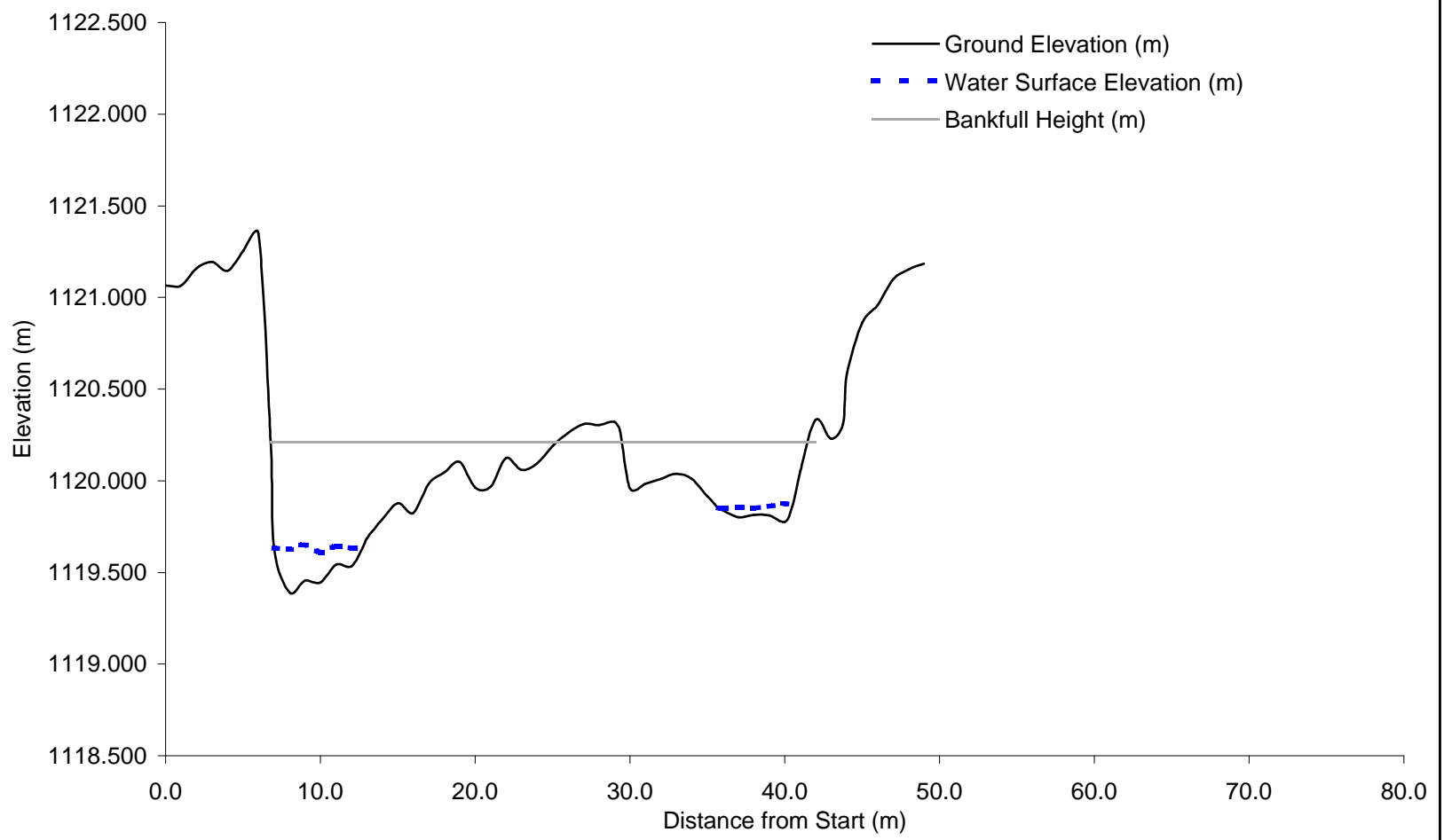
Benchmark elevations:

BM2: 1124.459

RP3: 1121.934

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
RP3	0.0	0.868			1121.066			RUB pin
1121.934 m	1.0	0.868			1121.066			
	2.0	0.775			1121.159			
	3.0	0.740			1121.194			
	4.0	0.790			1121.144			
	5.0	0.680			1121.254			
	6.0	0.585			1121.349			undercut bank
	6.8	1.720			1120.214		gravel	RUB bankfull height, undercut bank
	7.0	2.300	0.000	2.3	1119.634	1119.634	cobble	RUB wetted edge
	8.0	2.544	0.235	2.309	1119.390	1119.625	cobble	
	9.0	2.478	0.195	2.283	1119.456	1119.651	cobble	
	10.0	2.490	0.165	2.325	1119.444	1119.609	cobble	
	11.0	2.391	0.100	2.291	1119.543	1119.643	gravel	
	12.0	2.402	0.100	2.302	1119.532	1119.632	cobble	
	12.8	2.296	0.000	2.296	1119.638	1119.638	cobble	LUB wetted edge
	13.0	2.250			1119.684		gravel	unvegetated bar
	14.0	2.144			1119.790		gravel	unvegetated bar
	15.0	2.056			1119.878		gravel	unvegetated bar
	16.0	2.109			1119.825		cobble	
	17.0	1.951			1119.983		cobble	
	18.0	1.888			1120.046		cobble	
	19.0	1.831			1120.103		cobble	
	20.0	1.971			1119.963		cobble	
	21.0	1.965			1119.969			
	22.0	1.812			1120.122			
	23.0	1.876			1120.058			

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
	24.0	1.839			1120.095		cobble	
	25.0	1.743			1120.191			bankfull height
	26.0	1.675			1120.259			
	27.0	1.626			1120.308			
	28.0	1.630			1120.304			
	29.0	1.613			1120.321			
	29.4	1.662			1120.272			
	30.0	1.977			1119.957			
	31.0	1.951			1119.983			
	32.0	1.925			1120.009			
	33.0	1.897			1120.037			
	34.0	1.924			1120.010			
	35.0	2.020			1119.914			
	35.7	2.081	0.000	2.081	1119.853	1119.853	gravel	wetted edge
	36.0	2.095	0.010	2.085	1119.839	1119.849	gravel	unvegetated bar
	37.0	2.133	0.055	2.078	1119.801	1119.856	gravel	
	38.0	2.120	0.035	2.085	1119.814	1119.849	gravel	
	39.0	2.124	0.050	2.074	1119.810	1119.860	cobble	
	40.0	2.158	0.100	2.058	1119.776	1119.876	cobble	
	40.5	2.073	0.000	2.073	1119.861	1119.861	gravel	LUB wetted edge
	41.0	1.880			1120.054		gravel	unvegetated bar
	42.0	1.603			1120.331		gravel	
	43.0	1.705			1120.229		gravel	LUB bankfull height
	43.8	1.625			1120.309			
	44.0	1.353			1120.581			
	45.0	1.070			1120.864			
	46.0	0.978			1120.956			
	47.0	0.835			1121.099			
	48.0	0.780			1121.154			
	49.0	0.750			1121.184			



Cross sectional profile of a representative riffle habitat unit of the Bighorn Creek in reach 1, study site 1.

Bighorn Creek

Differential Levelling Loop - Reach 1, Site 1

Station	Backsight	Height of Instrument	Foresight	Elevation	Comment	Corrected Data	True Elevation (m)
BM2	0.391	5.391		5.000	arbitrary elevation	5.000	1124.459 (from 1999 survey)
RP4	0.898	4.796	1.493	3.898		3.902	1123.361
RP3	0.864	3.330	2.33	2.466		2.470	1121.929
RP2		0.985	2.345	0.985		0.989	1120.448
RP2	2.345	3.330		0.985		0.989	1120.448
RP3	2.18	4.655	0.855	2.475		2.479	1121.938
RP4	1.48	5.385	0.75	3.905		3.909	1123.368
BM2			0.408	4.977	error = -0.023		

Benchmark Elevations (m)	
BM2	1124.459
RP2	1120.448
RP3	1121.934
RP4	1120.364